PB-241 916

DEVELOPMENT DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS FOR THE FABRICATED AND RECLAIMED RUBBER SEGMENT OF THE RUBBER PROCESSING POINT SOURCE CATEGORY

Environmental Protection Agency

December 1974

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154124

PB 241 916

EPA 440/1-74/030-a
Group I, Phase II

Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the

FABRICATED AND RECLAIMED RUBBER

Segment of the

RUBBER PROCESSING

Point Source Category

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DECEMBER 1974

PB241916

BIBLIOGRAPHIC DATA SHEET

1. Report No. EPA-440/1-74/030-a

2.

4. Title and Subtitle Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Fabricated and Reclaimed Rubber Segment of the Rubber Processing Point Source Category

5. Report Date December 1974

6.

7. Author(s) Richard J. Kinch

8. Performing Organization Rept. No. EPA-440/1-74/030-a

9. Performing Organization Name and Address

Environmental Protection Agency
Effluent Guidelines Division
Rm 913, WSM-E 401 M Street, S.W.
Washington, D. C. 20460

10. Project/Task/Work Unit No. N/A

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

Same as Item 9.

13. Type of Report & Period Covered Final

14.

15. Supplementary Notes

16. Abstracts

This document presents the findings of an extensive study of the rubber processing industry for the purpose of recommending Effluent Limitations Guidelines, Federal Standards of Performance, and Pretreatment Standards for the Industry for the purpose of implementing Sections 304, 306, and 307, of the "Act".

Effluent Limitations guidelines are set forth for the degree of effluent reduction attainable through the application of the "Best Practicable Control Technology Currently Available" and the "Best Available Technology Economically Achievable" which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The "Standards of Performance for New Sources" set forth a degree of effluent reduction which is achievable through the application of best available demonstrated control technology processes, operating methods or other alternatives.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

PRICES SUBJECT TO CHANGE

18. Availability Statement

GPO
Washington, D. C.

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page UNCLASSIFIED

21. No. of Pages 243

22. Price 7.50 /8.25

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

DEVELOPMENT DOCUMENT
for
EFFLUENT LIMITATIONS GUIDELINES
and
NEW SOURCE PERFORMANCE STANDARDS
for the
FABRICATED AND RECLAIMED RUBBER SEGMENT OF THE RUBBER PROCESSING POINT SOURCE CATEGORY

Russell E. Train
Administrator

James L. Agee
Assistant Administrator for Water and
Hazardous Materials

Allen Cywin
Director, Effluent Guidelines Division

Richard J. Kinch
Project Officer

December, 1974

Effluent Guidelines Division
Office of Water and Hazardous Materials
U.S. Environmental Protection Agency
Washington, D. C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

ABSTRACT

This document presents the findings of an extensive study of the rubber processing industry to develop effluent limitations guidelines, Federal standards of performance, and pretreatment standards for the industry, to implement sections 304, 306, and 307 of the Federal Water Pollution Control Act, as amended (33 USC 1251, 1314, and 1316; 86 Stat 816).

Effluent limitations guidelines contained herein set forth in the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best available technology economically achievable, which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The Standards of Performance for new sources contained herein set forth the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

The development of data and recommendations in the document relate to the overall rubber processing industry which is divided into four major segments: general molded, extruded and fabricated rubber products, wet digester rubber reclaiming, pan (heater), mechanical and dry digestion rubber reclaiming and latex-based products. The industry has been further subcategorized into seven subcategories on the basis of the characteristics of the manufacturing processes involved. Separate effluent limitations were developed for each category on the basis of the level of raw waste load as well as on the degree of treatment achievable by suggested model systems. These systems include both biological and physical/chemical treatment.

Supportive data and the rationale for development of the effluent limitations guidelines and standards of performance are contained in this report.

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SECTION I

CONCLUSIONS

There are three major groupings in the fabricated and reclaimed rubber segment of the rubber processing industry which this report encompasses. These groupings, determined on the basis of raw materials used or products produced, include: 1) General Molded, Extruded, and Fabricated Products; 2) Reclaimed Rubber; and 3) Latex-based Products.

Subcategories referred to within the development document are labeled according to the corresponding Subpart used in the Federal Register. Therefore, since Subpart E within the Federal Register refers to small-sized General Molded, Extruded and Fabricated Rubber Plants, this subcategory will be referred to as Subcategory E. The subcategories will be referred to as follows:

Subcategory E - Small-sized General Molded, Extruded, and Fabricated Rubber Plants

Subcategory F - Medium-sized General Molded, Extruded, and Fabricated Rubber Plants

Subcategory G - Large-sized General Molded, Extruded, and Fabricated Rubber Plants

Subcategory H - Wet Digestion Reclaimed Rubber

Subcategory I - Pan, Dry Digestion, and Mechanical Reclaimed Rubber

Subcategory J - Latex-dipped, Latex-extruded, and Latex-molded Goods

Subcategory K - Latex Foam

For the purpose of establishing effluent limitations, General Molded, Extruded, and Fabricated Rubber Products has been subcategorized by facility size, as determined by usage of raw materials. Process waste water flow rates and loadings and costs of control technologies substantiate this breakdown. Factors such as manufacturing process, final product, raw materials, plant age, geographical location, air pollution equipment, and the nature and treatability of the waste waters are similar within each size subcategory and further substantiate the subcategorization.

Process waste waters evolved from facilities within Subcategories E, F, and G include discharges of processing solutions, washdown of plant areas, runoff from outdoor storage areas, spills and leaks of organic solvents and lubricating oils, and vulcanizer condensate. Primary pollutants (or indicators of pollution) in these waste waters are oil and grease, suspended solids, and acidity and/or alkalinity (pH). Lead and COD are other pollutants of importance encountered in hose fabrication which employs lead-sheathed or cloth-wrapped cures.

To be controlled and treated, process waste waters must be isolated from other nonprocess waste waters such as service water discharges and uncontaminated storm runoff. Treatment of process waste waters in a combined process/nonprocess system is ineffective because the relatively large volume of nonprocess waste waters dilute the contaminated process waste waters. Segregated processing solutions such as anti-tacking agents can be containerized. Segregated oily process waste waters can be treated in an API-type separator followed by a filter coalescer.

Reclaimed Rubber has been further subdivided in this study based on the process employed. Subcategory H -- Wet Digestion Rubber Reclaiming employs a wet process; Subcategory I -- Pan (Heater), Mechanical, and Dry Digestion Rubber Reclaiming utilizes dry processes. Process waste water flow rates and loadings substantiate this subcategorization.

Process waste waters evolved by both Subcategory H and Subcategory I plants include discharges of processing solutions, washdown and runoff from all plant areas, spills and leaks of organic solvents and lubricating oils, and discharges from wet air-pollution control devices. An additional process waste water evolved by the Wet Digestion process (Subcategory H) is dewatering liquor. No additional process waste waters are evolved in the dry processes (Subcategory I). Primary pollutants (or indicators) are COD, oil and grease, suspended solids, and acidity and/or alkalinity (pH).

The technologies necessary to control and treat waste waters from the Pan (heater), Dry Digestion, and Mechanical processes (Subcategory I) are similar to those employed for the Molded, Extruded and Fabricated Rubber subcategories. These include isolation of process waste streams, containment of processing solution wastes, and treatment of other process waste waters for suspended solids and oil.

Treatment of processing waste waters from the Wet Digestion process involves isolation and containment of processing solutions and the recycle and reuse of oil-contaminated dewatering liquors and discharges from wet air-pollution equipment.

The Latex-based Products have been subcategorized based on the process, plant size, waste water characteristics, and treatability of the waste waters. There are two subcategories: Subcategory J, the latex-dipped, latex-extruded, and latex-molded products; and Subcategory K, latex foam.

Process waste waters evolved from both subcategories include product wash and rinse waters and spills, and washdown from processing areas, and runoff from outdoor storage areas. Primary pollutants (or indicators) are COD, BOD, suspended solids, oil, and acidity and/or alkalinity (pH). In addition, zinc is present in process waste waters evolved at latex foam facilities. When chromic acid is used as a form-cleaning agent, chromium will be present in the process waste waters from latex-dipped or latex-molded facilities.

The technologies identified to control and treat waste waters from the production of latex-based products (Subcategory J and Subcategory K) include segregation of process waste water streams, coagulation and clarification of latex-laden waste waters, and biological treatment. In addition, chemical precipitation of zinc in rinse waters at facilities producing latex foam may be utilized to comply with zinc limitations.

SECTION II

RECOMMENDATIONS

Process waste waters evolved from sources within the General Molded, Extruded, and Fabricated Rubber Plants Subcategories should be treated for suspended solids, oil and grease, lead (where applicable), and pH. Limitations and standards for the best practicable control technology currently available are based on raw material usage. For plants consuming less than 3,720 kg/day (8,200 lbs/day) of raw materials these are:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	0.70	0.25
TSS	1.28	0.64
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Oil and grease	0.70	0.25
TSS	1.28	0.64
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to lead-sheathed hose production are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Lead	0.0017	0.0007

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(English units)	lb/1000 lb of raw material	
Lead	0.0017	0.0007

For plants utilizing wet scrubbers, an additional allowance for TSS is as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	5.8	2.9
(English units)	lb/1000 lb of raw material equivalent	
TSS	5.8	2.9

For plants consuming between 3,720 kg/day (8,200 lbs/day) and 10,430 kg/day (23,000 lbs/day) of raw materials the limitations and standards are:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	0.42	0.15
TSS	0.80	0.40
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Oil and grease	0.42	0.15
TSS	0.80	0.40
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to lead-sheathed hose production are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Lead	0.0017	0.0007
(English units)	lb/1000 lb of raw material	
Lead	0.0017	0.0007

For plants utilizing wet scrubbers, an additional allowance for TSS is as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	5.8	2.9
(English units)	lb/1000 lb of raw material equivalent	
TSS	5.8	2.9

Finally, for plants using raw material at a rate greater than 10,430 kg/day (23,000 lbs/day) the recommended effluent standards are:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty

	----------	consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	0.26	0.093
TSS	0.50	0.25
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Oil and grease	0.26	0.093
TSS	0.50	0.25
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to lead-sheathed hose production are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day ----------	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Lead	0.0017	0.0007
(English units)	lb/1000 lb of raw material	
Lead	0.0017	0.0007

For plants utilizing wet scrubbers, an additional allowance for TSS is as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day ----------	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	5.8	2.9

(English units)	lb/1000 lb of raw material equivalent	
TSS	5.8	2.9

For all three subcategories; BPCTCA, BATEA, and NSPS are equivalent except for the allowance for wet scrubbers which for NSPS is zero, and for BATEA is:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	1.0	0.5
(English units)	lb/1000 lb of raw material equivalent	
TSS	1.0	0.5

The incremental treatment costs to the small- and medium-sized plants are high. Compared to the cost of rubber raw material (approximately 30 to 50 cents per pound), the treatment costs appear to be a burden on the small plants in particular. This analysis underlines clearly the cost benefits to be derived by complete elimination of process waste waters by good housekeeping and closed spill and leak containment facilities or by utilization of the local municipal treatment system. In addition, the elimination of direct discharge of process waters to navigable waters will eliminate the expense of waste water analyses and permit reporting.

Process waste waters evolved from the Wet Digestion Rubber Reclaiming industry (Subcategory H) are contaminated with BOD, COD, suspended solids, oil and pH.

Limitations and standards for BPCTCA are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for	Average of daily

	any one day	values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of product	
COD	14.7	6.11
Oil and grease	0.40	0.144
TSS	1.04	0.52
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of product	
COD	14.7	6.11
Oil and grease	0.40	0.144
TSS	1.04	0.52
pH	Within the range 6.0 to 9.0.	

For Subcategory H, no additional reduction is recommended for the limitations and standards on COD, suspended solids, or oil represented by the best available technology economically achievable or for new sources coming on stream after the guidelines are put into effect. It is recognized that no reclaimed rubber sources using the wet digestion process are likely to come on stream. Reasonable alternatives to the Wet Digestion process are the pan, dry digester or mechanical processes. These processes generate a less contaminated waste water and, according to industry spokesmen, are economically more favorable.

Process waste waters evolved from the Pan, Dry Digestion or Mechanical Rubber Reclaiming industry (Subcategory I) should be treated for suspended solids, oil and pH. Limitations and standards for the best practicable control technology currently available are based on raw material usage and are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of product	
Oil and grease	0.40	0.144
TSS	0.384	0.192
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of product	

Oil and grease	0.40	0.144
TSS	0.384	0.192
pH	Within the range 6.0 to 9.0.	

The following COD limitations may apply to pan, dry digestion, and mechanical reclaimed rubber processes integrated with a wet digestion process.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of product	
COD	6.7	2.8
(English units)	lb/1000 lb of product	
COD	6.7	2.8

No additional reduction is recommended for the limitations represented by the best available technology economically achievable or for new sources coming on-stream after the guidelines are put into effect.

Contaminants in the process waste waters evolved from latex-dipped, latex-extruded and latex-molded operations (Subcategory J) should be controlled and treated for BOD, suspended solids, oil, chromium, and pH. The limitations and standards for the best practicable control technology currently available are based on total latex solids consumption and are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	2.0	0.73
BOD$_5$	3.72	2.20
TSS	6.96	2.90
pH	Within the range 6.0 to 9.0.	

(English units)	lb/1000 lb of raw material	
Oil and grease	2.0	0.73
BOD$_5$	3.72	2.20
TSS	6.96	2.90
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to chromic acid form cleaning operations are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Chromium	0.0086	0.0036
(English units)	lb/1000 lb of raw material	
Chromium	0.0086	0.0036

No additional reduction is recommended for the limitations represented by the best available technology economically achievable or for new sources coming on-stream after the guidelines are put into effect.

Contaminants in process waste waters evolved from latex foam operations (Subcategory K) include BOD, suspended solids, zinc, and pH. The limitations for the best practicable control technology currently available are based on total latex solids consumption and are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Zinc	0.058	0.024

BOD$_5$	2.4	1.4
TSS	2.26	0.94
pH	Within the range 6.0 to 9.0.	

(English units)	lb/1000 lb of raw material	
Zinc	0.058	0.024
BOD$_5$	2.4	1.4
TSS	2.26	0.94
pH	Within the range 6.0 to 9.0.	

No additional reduction is recommended for the limitations represented by the best available technology economically achievable or for new sources coming on-stream after the guidelines are put into effect.

SECTION III

INTRODUCTION

Purpose and Authority

Section 301(b) of the Act requires the achievement, by not later than July 1, 1977, of effluent limitations for point sources (other than publicly owned treatment works) which are based on the application of the "best practicable control technology currently available" as defined by the Administrator pursuant to Section 304(b) of the Act.

Section 301(b) also requires the achievement, by not later than July 1, 1983, of effluent limitations for point sources (other than publicly owned treatment works) which are based on the application of the "best available technology economically achievable" which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) of the Act.

Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants that would reflect the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the "best available demonstrated control technology, processes, operating methods, or other alternatives", including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish, within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth:

1. The degree of effluent reduction attainable through the application of the best practicable control technology currently available.

2. The degree of effluent reduction attainable through the application of the best control measures and practices achievable (including treatment techniques, process and procedure innovations, operation methods, and other alternatives).

The regulations herein set forth effluent limitation guidelines pursuant to Section 304(b) of the Act for the fabricated and reclaimed rubber segment of the rubber processing industry which encompasses the

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manufacturer of rubber footwear, reclaimed rubber, rubber hose and belting, miscellaneous fabricated rubber products, rubber gaskets, rubber packing and retreaded tires.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b) (1) (A) of the Act, to propose regulations establishing Federal standards of performances for new sources within such categories. The Administrator published, in the Federal Register of January 16, 1973 (38 F.R. 1624), a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the rubber footwear, reclaimed rubber, rubber hose and belting, miscellaneous fabricated rubber products, rubber gaskets, rubber packing and sealing devices, tire retreading, and polysulfide synthetic rubber subcategories of the Rubber Processing Industry, which were included in the list published on January 16, 1973.

The guidelines in this document identify (in terms of chemical, physical, and biological characteristics of pollutants) the level of pollutant reduction attainable through the application of the best practicable control technology currently available and the best available technology economically achievable. The guidelines also specify factors which must be considered in identifying the technology levels and in determining the control measures and practices which are to be applicable within given industrial categories or classes.

In addition to technical factors, the Act requires that a number of other factors be considered, such as the costs or cost-benefit study and the environmental impacts not related to water quality (including energy requirements) resulting from the application of such technologies.

Summary of Methods Used for Development of the Effluent Limitations Guidelines and Standards of Performance

The effluent limitation guidelines and standards of performance herein were developed in a stepwise manner.

The development of appropriate industry categories and subcategories and the establishment of effluent guidelines and treatment standards require a sound understanding and knowledge of the rubber industry, the processes involved, water use, recycle and reuse patterns, characteristics of waste water, the respective raw waste loadings, and the capabilities of existing control and treatment methods.

Initial categorizations and subcategorizations were based on raw materials used, product produced, manufacturing process employed, and other factors such as plant age. Published literature was consulted to verify raw waste characteristics and treatabilities in order to support the initial industry categorizations and subcategorizations. The raw waste characteristics for each tentative subcategory were then fully identified. Factors considered in this analysis were: the supply and volume of water used in the process employed; the sources of waste and waste waters in the plant; and the constituents, including thermal effects, of all waste waters together with those contaminants which are toxic or result in taste, odor, and color in water or aquatic organisms. The constituents of waste waters which should be subject to effluent limitations guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each subcategory was identified. This involved an identification of each distinct control and treatment technology (including both in-plant and end-of-pipe technologies) which are existent or capable of being designed for each subcategory. It also included an identification in terms of the amount of constituents (including thermal effects), the chemical, physical, and biological characteristics of pollutants, and the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations/reliability of each treatment and control technology, and the required implementation time were also identified to the extent possible. In addition, the environmental impact not pertaining to water quality, such as the effects of the application of such technologies upon other pollution problems (including air, solid waste, noise, and radiation) was also identified to the extent possible. The energy requirements of each of the control and treatment technologies were identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the "best practicable control technology currently available", the "best available technology economically achievable", and the "best available demonstrated control technology, processes, operating methods, or other alternatives for new sources". In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and the application of various types of control technique process changes, the environmental impact aside from water quality (including energy requirements), and other factors.

Raw waste water characteristics and treatability data, as well as information pertinent to treatment reliability and cost evaluations, were obtained from several sources, including: EPA research information, published literature, Corps of Engineers Permit to Discharge Applications, industry historical data, and expert industry consultation.

On-site visits and interviews were made to selected rubber processing plants throughout the United States, to confirm and supplement the foregoing data. All factors potentially influencing industry subcategorizations were represented in the on-site visits. Detailed information was obtained on production schedules and capacities and on product breakdowns, and also on management practices for water use and for waste water control and treatment. Flow diagrams showing water uses and process waste water stream interactions were prepared. Control and treatment design data and cost information were compiled. Individual, raw and treated effluent streams were sampled and analyzed to confirm company-furnished data in order to characterize the raw wastes and determine the effectiveness of the control and treatment methods. Duplicate samples were analyzed by participating companies to confirm the analytical results; some of the results from the analysis of duplicate samples conflicted with the contractors analysis. Data received from all sources were evaluated in the determination of the limitations.

General Description of the Industry

The SIC codes pertinent to the fabricated and reclaimed rubber segment of the rubber processing industry are as follows:

Rubber Footwear	SIC 3021
Reclaimed Rubber	SIC 3031
Rubber Hose and Belting	SIC 3041
Miscellaneous Fabricated Rubber Products	SIC 3069
Rubber Caskets, Packing, and Sealing Devices	SIC 3293
Tire Retreading	SIC 7534

With the exception of reclaimed rubber, and miscellaneous rubber products fabricated from latex rubber, the processing operations of the fabricated and reclaimed rubber segment are based on mechanical and dry manufacturing processes. Such processes typically are: molding, extruding, sheeting, foaming, coating, fabrication of sections, and vulcanization. The initial manufacturing operations involve batch treatment of the stock to incorporate colorants, extenders, reinforcers, and special additives such as accelerators and antioxidants. After the batching step, the production operations are usually continuous, semi-continuous, or batch-continuous.

Rubber reclaiming utilizes several diverse process technologies which differ considerably from those processes used by the other product areas of the rubber industry included in this document. Reclaimed rubber processes are by nature mechanical, dry, or wet. Since the waste water impacts of these process types are dissimilar as well as distinct from other processes used in the industry, it is appropriate to describe and evaluate the process technologies, water uses, and generated waste waters of rubber reclaiming separately.

Although rubber items produced from latex rubber are included in SIC 3069, the processes employed and the nature of the waste water are such that this type of operation warrants separate description and evaluation. The factor justifying separate discussion is the use of latex as a raw material. Because of this, the processing operations are different from those used in other product areas of the industry. As a result, there is potential to generate latex-laden waste waters which are distinct in their characteristics, properties, and treatability.

Based on the foregoing discussion, the fabricated and reclaimed rubber segment covered by this document can be grouped into three (3) broad classifications based on product and processing type:

1. Regular Rubber Products

    a) General Molded Products found under SIC 3069 and including Gaskets, Packing, and Sealing Devices (SIC 3293).

    b) General Extruded Products found under SIC 3069 and including Rubber Belting as classified under SIC 3041.

    c) General Fabricated Products found under SIC 3069 including Rubber Footwear (SIC 3021), Tire Retreading (SIC 7534), and Rubber Hose as classified under SIC 3041.

2. Reclaimed Rubber (SIC 3031).

3. General Latex-based Products found under SIC 3069.

Manufacture of General Molded Products

Rubber products made by molding processes are diverse in size, shape and end use. Owing to the product diversity and wide distribution of manufacturers, it is extremely difficult to determine the magnitude of the various product types forming the broad molded product industry in terms of either weight of rubber consumed or weight of finished products. Table 1 presents, in a relative sense, the most complete and up-to-date data available on the magnitude of the various product elements within the general molded product industry. Table 1 shows the dollar value of the 1967 shipments for each product type.

During the molding of rubber products, the rubber is cured as it is shaped. Curing, which is often referred to as vulcanization, is an irreversible process during which a rubber compound, through a change in its chemical structure (for example, crosslinking), becomes less

Product Type	Value (million dollars)
Battery Parts	69.9
Miscellaneous Automotive Parts	237.8
Seals, Packing, etc.	145.3
Rubber Rolls	32.8
Rubber Heels and Soles	126.1
Druggist and Medical Supplies [1]	36.7
Stationery Supplies[2]	16.3
Small Molded Items[3]	106.6
Other Miscellaneous Molded Items	146.4
Total	917.9

[1] For example, water bottles, fountain syringes, nipples, and pacifiers.

[2] For example, rubber bands, finger cots, and erasers.

[3] For example, rubber brushes, combs, and mouth pieces.

SOURCE: "1967 Census of Manufacturers -- Rubber and Miscellaneous Plastic Products"; U. S. Department af Commerce (issued 1970).

Table 1 - 1967 Shipments of General Molded Products by U.S. Producers

plastic and more resistant to swelling by organic liquids. In addition, elastic properties are conferred, improved, or extended over a greater range of temperature. The term "vulcanization" was originally employed to denote the process of heating rubber with sulfur, but has now been extended to include any process with any combination of materials which will produce this effect.

Several methods are used to mold rubber products. The selection of a particular molding technique is dependent on the nature of the product, the type of rubber, and the production economics. The principal methods used for the manufacture of general molded products are the compression, transfer, and injection molding processes. In many cases compression, transfer, and injection molding techniques are all used at one plant location.

Rubber molding processes typically consist of the following:

1. Compounding of the rubber stock.
2. Preparation of the mold preforms or blanks.
3. Molding.
4. Deflashing.

A flow diagram for a typical molding operation involving compression, transfer, and injection molding processes is shown in Figure 1.

Compression Molding

Compression molding is the oldest method of making molded parts. The uncured rubber is formed to the approximate shape, referred to as a preform, and placed in the individual cavities of the mold. As the mold is closed under pressure, the compound conforms to the shape of the cavity and the excess material is forced out into a flash groove.

Larger molding facilities, or plants using special rubber compound recipes, compound their own rubber stock from basic ingredients such as rubber, carbon black, colorants, extender oils, antioxidants, and accelerators. Compounding is generally carried out in either a Banbury mixer or compounding mill. These pieces of equipment require cooling water. Leakages of lubricating oil and grease are common. In some plants, airborne particles generated during the compounding operation are controlled by wet scrubbing devices.

After compounding, the rubber stock is worked on a warm-up mill and formed to approximately the required shape ready for molding by either a calender or extruder. The formed rubber is cooled and generally dipped in an anti-tack agent. In many cases, the formed rubber is cooled in an open tank which produces a cooling water overflow. The anti-tack liquid is generally a zinc stearate solution or its equivalent. Soapstone slurry is not normally used because its anti-tack properties are persistent and adversely affect the quality of the

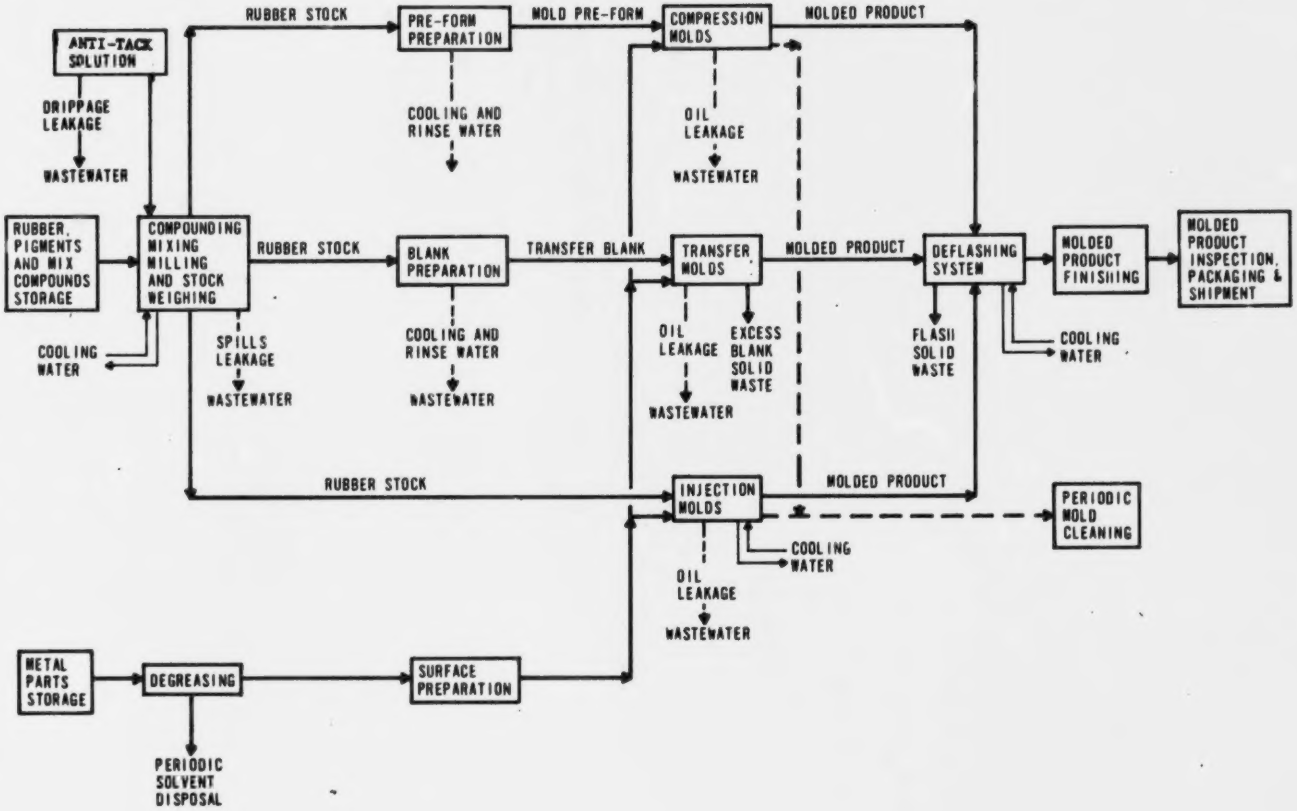

ANTI-TACK SOLUTION
DRIPPAGE LEAKAGE
WASTEWATER
RUBBER, PIGMENTS AND MIX COMPOUNDS STORAGE
COMPOUNDING MIXING MILLING AND STOCK WEIGHING
COOLING WATER
SPILLS LEAKAGE
WASTEWATER
RUBBER STOCK
PRE-FORM PREPARATION
COOLING AND RINSE WATER
MOLD PRE-FORM
COMPRESSION MOLDS
OIL LEAKAGE
WASTEWATER
MOLDED PRODUCT
RUBBER STOCK
BLANK PREPARATION
COOLING AND RINSE WATER
WASTEWATER
TRANSFER BLANK
TRANSFER MOLDS
OIL LEAKAGE
WASTEWATER
EXCESS BLANK SOLID WASTE
MOLDED PRODUCT
DEFLASHING SYSTEM
FLASH SOLID WASTE
COOLING WATER
MOLDED PRODUCT FINISHING
MOLDED PRODUCT INSPECTION, PACKAGING & SHIPMENT
RUBBER STOCK
INJECTION MOLDS
MOLDED PRODUCT
COOLING WATER
OIL LEAKAGE
WASTEWATER
PERIODIC MOLD CLEANING
METAL PARTS STORAGE
DEGREASING
PERIODIC SOLVENT DISPOSAL
SURFACE PREPARATION

FIGURE 1: FLOW DIAGRAM FOR THE PRODUCTION OF A TYPICAL MOLDED ITEM

subsequent molding operation. The preforms are prepared from the calendered or extruded stock rubber by cutting, slicing or stamping out. Cutting can be accomplished by a machine or by hand. Slicing is generally carried out on a meat slicing machine or guillotine. In the case of the slicing machine, lubricant water flows over the cutting surface to facilitate the operation. The waste lubricant water is noncontaminated. The preform stamping machine can be equipped with cooling water. Although the exact shape of the preform is not crucial, it is necessary to ensure that there is sufficient rubber in the preform to fill the mold.

The preforms are placed in the open mold, usually by hand. In some cases release agent powders or liquids are spread on the mold surfaces. For small molded items, each mold generally has multiple receptacles which enable several items to be molded simultaneously. The mold is closed and held together, normally by hydraulic oil pressure, during the curing cycle. The molds are generally heated with steam flowing through channels in the mold plates. Steam condensate is recycled to the boiler. Some older mold systems are electrically heated. Oil leakage frequently occurs from the hydraulic mold closing systems and the hydraulic pump itself. The molding cycle can vary considerably depending on the curing properties of the rubber and the size of the molded item. At the conclusion of the molding cycle, the items are removed from the mold and sent to the deflashing operation.

The rubber overflow or flash must be removed from the part before it is shipped. Deflashing usually is carried out by hand, grinding wheel, or press-operated dies. In some cases, the rubber parts are tumbled in dry ice (solid carbon dioxide) using machines that are similar to cement mixers. The thin rubber flash becomes brittle while the main body of the part is not cooled sufficiently and remains flexible. The thinner frozen flash thus breaks off in tumbling while the heavier main part is not harmed. Blasting frozen rubber parts with fine shot also removes flash. Rubbers which are freeze-resistant are not used in this dry-ice process.

Metal-bonded items, which consist of a molded rubber component bonded to the metal part, are manufactured in a manner similar to that for all rubber products. In most cases the metal parts enter the molding plant contaminated by grease. The grease is picked up during the manufacture of the metal part or is applied for shipping and storage purposes.

The metal part is first degreased. Usually the degreasing system consists of a rotating drum in which the part is brought in contact with a suitable degreasing solvent, frequently trichloroethylene. The solvent is drummed and hauled from the plant when saturated with grease. In a few cases the metal part is pickled to prepare the surface for bonding with rubber. The waste acid pickling liquor contains metal ions, and frequently heavy metal ions, and requires containerization or treatment before it is discharged.

In some molding plants, poor quality molded items are recycled to reclaim the metal component for re-use. This is generally practiced in cases where the metal part is large or valuable, or where the molding operation is particularly difficult, producing a high proportion of rejected molded items. To reclaim the metal, the reject rubber is ground and buffed from the metal; the metal item is then sand-blasted clean. The grinding and buffing operations generally create airborne rubber-buffing particles, which are most effectively removed from the air with wet scrubbing devices. These devices produce a wastewater discharge which, if a water recycle system is used, can be reduced to a low daily volume.

The metal surface to which the rubber is to be molded is normally prepared to provide good adhesion between the metal and the rubber. The mating surface of the metal part is first sand blasted to roughen it and then coated with rubber cement to improve the adhesion of metal to rubber. The metal surface is painted with cement by hand for small items; larger metal surfaces are often sprayed with cement.

The prepared metal part and its mating rubber component are placed in the mold cavity and molded in a similar manner to an all-rubber product. Deflashing is generally carried out by hand or with a grinding wheel. One of the disadvantages of compression moldings is that the flash tends to be largest at the thick side of the molded item, making removal by tumbling difficult or impossible. The cost of preparing individual preforms and the placing of each in the mold cavity is another disadvantage of compression molding.

Transfer Molding

Transfer molding involves the transfer of the uncured rubber stock from one part of the mold to another. The stock, in the form of blanks, is placed in a recess called the pot or transfer cavity. The pot is fitted with a ram or piston which is inserted over the stock. The force of the press when applied to the ram plus the heat from the mold causes the stock to be softened and flow through runners into the previously empty molding cavities, where the stock is cured in the desired form.

The rubber for transfer molding is compounded in the same way as that for compression molding. The rubber stock blanks, which are fed into the transfer pot of the mold, are generally cut from extruded or sheeted-out rubber stock and take the form of slabs. Frequently, the weight of the rubber blank is brought within a certain weight tolerance by trimming overweight blanks. Underweight blanks and the trimmings are recycled to the sheet-out mill. The weight of the blank is regulated to ensure that sufficient rubber is available in the transfer pot to fill the mold cavities.

Transfer molds are normally heated by steam and are operated by hydraulic oil systems similar to compression mold hydraulic systems. Oil leaks and spillages are frequent. Curing times in the mold are similar to those of compression molds and likewise are based on product dimension and rubber stock properties.

When the mold is opened the item is pulled or cut from the runners. The runners and the residual rubber in the transfer pots are discarded as waste. The molded item is deflashed by methods similar to those described above for compression molded products.

Articles containing metal inserts are generally manufactured by transfer molding and the overall processes are very comparable to those used in compression molding including the preparation of the metal component.

Transfer molding permits closer dimensional control and generally reduces flash so that the parts can be easily finished. Complex shapes can be readily manufactured by this method. Small parts can be made more economically by this technique because of the labor cost savings on preforms and finishing. The disadvantages of this method are that the formulations and control of stocks are much more critical than with compression molds. Stocks must flow well and knit properly, and still cure relatively fast. As explained above, the small amount of compound remaining in the transfer pot, as well as the material in the runners, is wasted. Therefore, this molding method requires careful cost calculations for scrap loss when making items requiring premium priced polymers such as the fluororubbers, silicones, and polyacrylates.

Transfer molds are more expensive and in general require more maintenance than compression molds.

Injection Molding

Injection molding is the newest method of molding and requires the greatest degree of sophistication both from the standpoint of materials and mold design. Basically, it is the same as transfer molding with the exception that the stock is injected into the cavities. There are essentially three different types of injection-molding machines. One machine uses a ram to force the stock through runners into the cavities; another uses a screw; the third is a combination of the first two and is a reciprocating screw. From the point of view of water use, there is little difference between the three types of machines. All require cooling water. In some cases the injection molding machines are equipped with their own closed-loop cooling systems.

The molds are often mounted on a revolving turret which takes the molds through a cyclic process. If required, the mold surfaces are treated with release agents followed by closing the mold before injection. Rubber is then injected into the closed mold after which the mold is opened and the molded item removed.

Deflashing of the molded item can be carried out by either hand or machine techniques similar to those methods used for the deflashing of compression and transfer molded products.

In order to make injection molding profitable, very short cycles are required which are generally in the 45-90 second range. This requires curing temperatures of approximating 400°F. Parts must be readily removed from the molds to keep the heat loss and cycle time to a minimum.

All the advantages mentioned for transfer molding apply to injection molding. Efficiency is greatest for a large volume of small items with relatively thin walls and of complicated shape.

Table 2 presents a review of potential process-associated waste water streams produced in the manufacture of molded items as described in the foregoing text.

Manufacture of General Extruded Products

As described above, rubber extrusion is used to prepare the preforms and blanks used in compression and transfer molding processes. The extrusion operation is a minor element of the overall production process for molded items. Rubber extrusion, however, plays a more significant role in the manufacture of such items as rubber belting and sheeting.

The types of extruded product are varied and the distribution of manufacturers is wide. Because of this, it is extremely difficult to compile complete data on the size of the extruded rubber products manufacturing in terms of weight of products or raw material usage. Table 3 gives an indication of the relative magnitude of the various types of extruded rubber products in terms of the 1967 dollar value of the shipments of those products.

Extruded rubber products can be grouped into two principal classes based on the nature of the manufacturing process. The simpler manufacture, such as sheeting production, involves essentially compounding, extrusion, and curing. On the other hand, items such as belting require a more involved manufacture consisting of all the above processes plus building. However, the building operation, as used in belting manufacture is a relatively straight forward process with little waste water impact. Therefore the manufacturing processes

Plant Unit or Area	Source	Nature and Origin of Waste Water Contaminants
Oil Storage	Spills and leaks	Oil pick-up by storm run-off
Compounding	Washdown, spills, leaks and discharges from wet air pollution control equipment	Solids from anti-tack dip tank Oil and water leaks from mixers and mills Solids from wet air pollution control equipment discharges
Blank and Pre-form Extrusion and Preparation	Rinse waters, spills and leakages	Rubber fines in lubricant and rinse water anti-tack agent in cooling tank overflow oil from machinery
Curing	Spills and leaks	Oil from hydraulically operated curing presses

Table 2 - Process-Associated Waste Water Sources from the Production of Molded Rubber Items

Product Type[1]	Value (million dollars)
Belting -- conveyor and elevator	88.2
Belting -- flat transmission	13.3
Sheeting -- mats, matting, stair treads	17.9
Sheeting -- floor and wall covering	16.1
Total	135.5

[1] Does not include V-belt type belting.

SOURCE: " 1967 Census of Manufacturers -- Rubber and Miscellaneous Plastic Products"; U. S. Department of Commerce (issued 1970).

Table 3 - 1967 Shipments of General Extruded Products by U.S. Producers[1]

used to produce rubber sheeting and belting will be described concurrently.

Sheeting and Belting

The majority of the processes used to manufacture sheeting and belting are very similar and serve as good examples of the production methods used to manufacture extruded items. A flow diagram for a typical extrusion production facility is presented in Figure 2; Table 4 presents the sources of waste water from extrusion facilities.

The rubber stock is compounded from the basic ingredients on a compounding mill or Banbury mixer. These pieces of machinery require cooling water. Leakage of lubricating oil and grease can occur. Wet scrubbers are sometimes used to control air pollution by airborne particles produced in the mixing area. In some cases the rubber is sheeted out on a sheeting mill and dipped in anti-tack slurry. Anti-tack leakage can occur in this area.

After compounding, the rubber is worked on a warm-up mill and fed to the extruder. The extruded rubber is produced as a sheet. In cases where the dimensions of the extruded rubber sheet are critical, the extruded rubber is calendered to the desired thickness. The extruded or calendered rubber is cooled in a cooling tank before storage for further processing. In some cases the extruded or calendered rubber is dipped in anti-tack slurry for storage.

Belting is manufactured by extruding the rubber onto the wire reinforcement in the extruder, or calendering the rubber sheeting onto reinforcement fabric that has been frictioned with rubber. Calenders require cooling water. Oil and grease leakage can be produced by the calendering machinery.

Belting or extruded and calendered sheeting is cured using a rotacure or press curing technique. A rotacure is an air heated drum. The sheeting and belting pass around the rotating drum and are cured. The press curing technique consists of two heated belts which hold the rubber belting or sheeting between them under pressure to facilitate the curing process. The heated belts turn and drag the sheeting or belting through the press. Cured belting or sheeting is inspected, cut to length, and stored before shipment.

In some plants a certain amount of the sheeting is shipped in an uncured state for use in the manufacture of tank linings and other large rubber items. Such sheeting is supplied from the extrusion or calendering line before the belting-formation or curing operations.

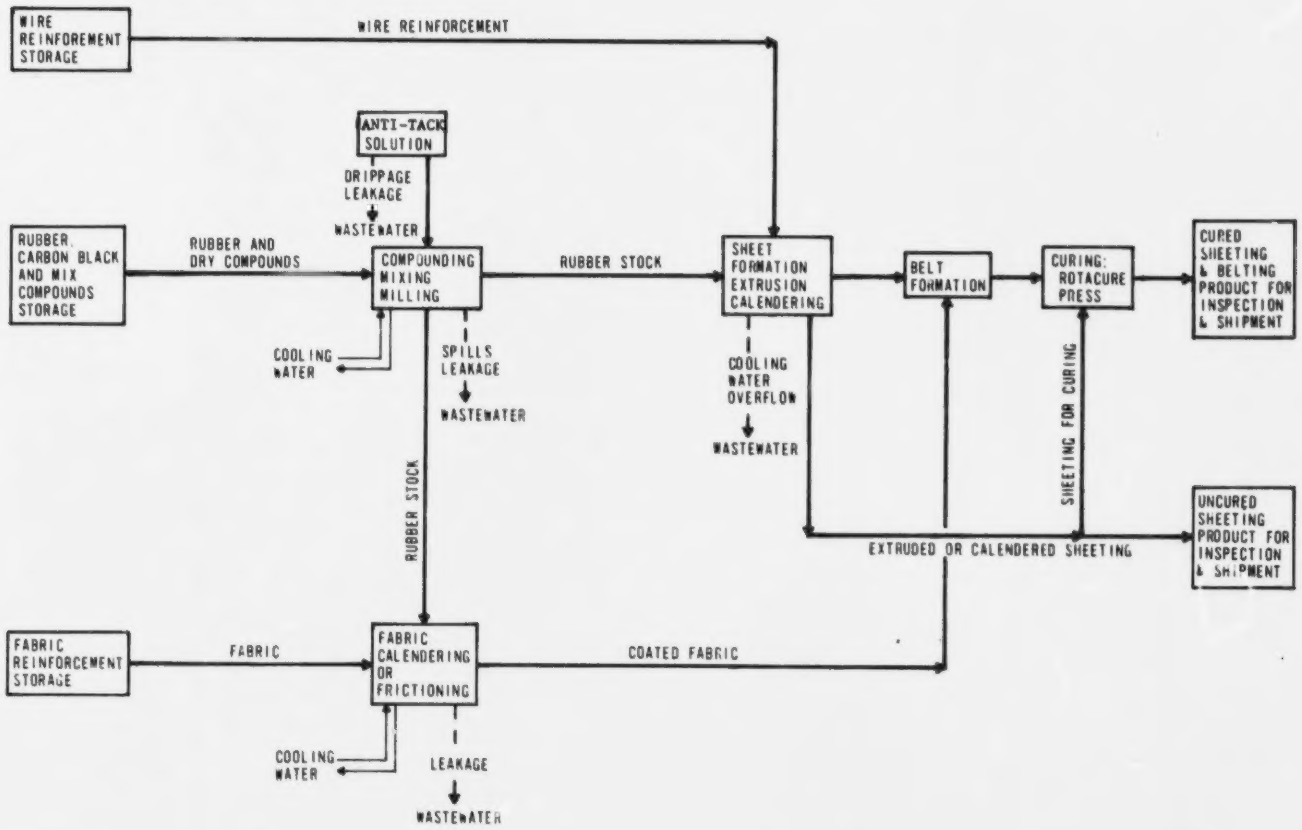

WIRE REINFOREMENT STORAGE
WIRE REINFORCEMENT
ANTI-TACK SOLUTION
DRIPPAGE LEAKAGE
WASTEWATER
RUBBER, CARBON BLACK AND MIX COMPOUNDS STORAGE
RUBBER AND DRY COMPOUNDS
COMPOUNDING MIXING MILLING
COOLING WATER
SPILLS LEAKAGE
WASTEWATER
RUBBER STOCK
SHEET FORMATION EXTRUSION CALENDERING
COOLING WATER OVERFLOW
WASTEWATER
BELT FORMATION
CURING: ROTACURE PRESS
CURED SHEETING & BELTING PRODUCT FOR INSPECTION & SHIPMENT
SHEETING FOR CURING
UNCURED SHEETING PRODUCT FOR INSPECTION & SHIPMENT
EXTRUDED OR CALENDERED SHEETING
RUBBER STOCK
FABRIC REINFORCEMENT STORAGE
FABRIC
FABRIC CALENDERING OR FRICTIONING
COATED FABRIC
COOLING WATER
LEAKAGE
WASTEWATER

FIGURE 2: FLOW DIAGRAM FOR THE PRODUCTION OF TYPICAL EXTRUDED ITEMS SUCH AS BELTING AND SHEETING

Plant Unit or Area	Source	Nature and Origin of Waste Water Contaminants
Oil Storage	Spills and leaks	Oil pick-up by storm run-off.
Compounding	Washdown, spills, leaks, and discharges from wet air pollution control equipment	Solids from anti-tack dip tank. Oil and water leaks from mixers and mills. Solids from wet air pollution control equipment discharges.
Extrusion	Cooling waters, spoils, and leakages	Anti-tack agent in cooling tank overflows, oil from machinery.
Calendering	Spills and leaks	Solids from anti-tack dip tank. Oil and water leaks from mixers and mills.
Curing[1]	Condensate	Organics and lead leached by steam vulcanizer condensate.
Testing[2]	Spills and leaks	Oil pick-up hydraulic testing water.

[1] Waste waters generated by curing operations are essentially limited to hose manufacture.

[2] Testing waters are used only in hose manufacture.

Table 4: Process-Associated Waste Water Sources from the Production of Extruded Rubber Products Including Rubber Hose and Belting (SIC 3041)

Manufacture of General Fabricated Products

The types of products and processes covered by this manufacturing description are varied. It can be said that general fabricated products is a catch-all for manufacturing types not included in the molded or extruded product groups. Processes employed are compounding, milling, fabrication, molding, and vulcanization.

Due to the diversity of the product types and the wide distribution of plants included in this manufacturing group, it is difficult to estimate the magnitude of rubber usage or product weight. Table 5 does show the relative magnitude of the various product types which constitute the manufacture of general fabricated products, in terms of the dollar value of the total 1967 U.S. shipments. Hose production provides a good example of rubber building or fabricated manufacturing processes. It can be seen from Table 5 that hose products constitute a major portion of the shipment value of extruded rubber products. Figure 3 illustrates the production steps of typical hose items.

Rubber hose generally consists of three components. They are the tube (lining), the reinforcement, and the outer cover.

The tube is the innermost rubber element. Some hose, such as a vacuum cleaner hose, does not have an inner lining or tube inside the reinforcement (usually a wire spiral). The primary function of the tube is to retain the transported material. The type and thickness of rubber used depends upon the intended service of the hose and the type of hose fitting or connecting device to be used.

The reinforcement is the fabric, cord, or metal elements built into the body of the hose to withstand internal pressure or external forces. The type of reinforcing material depends upon the method of manufacture and the service conditions. The rubber used to bond together the individual elements of the reinforcing material is considered a part of the hose reinforcement.

The cover is the outermost element. It is normally made of rubber and its prime function is to protect the reinforcement from outside damage or abuse.

While most hose is used for pressure service, there are many applications where an essential property of the hose is its resistance to collapse under suction and vacuum service. The usual method of preventing hose carcass collapse is to build a metal reinforcement, generally a steel wire spiralled in the form of a helix, into the body of the hose.

Hose manufacture can be classified according to the manner in which the hose is produced. Such factors as service, size, production volume, and cost usually determine the method by which the hose is made. The greatest proportion of all hose manufactured today is produced by highly mechanized equipment specially designed for the

Product Type	Value (million dollars)
Rubber Hose	398.8
Canvas Footwear	276.1
Waterproof Footwear[1]	75.3
Other Rubber Footwear	14.2
Friction Tape	19.0
Fuel Tanks	21.5
Boats, pontoons, and life rafts	15.0
Rubber coated fabrics	15.5
Rubber Clothing	10.7
Total	846.1

[1] Includes items manufactured by cement dipping.

Source: "1967 Census of Manufacturers -- Rubber and Miscellaneous Plastic Products"; U. S. Department of Commerce (issued 1970).

Table 5 - 1967 Shipments of General Fabricated Products by U.S. Producers

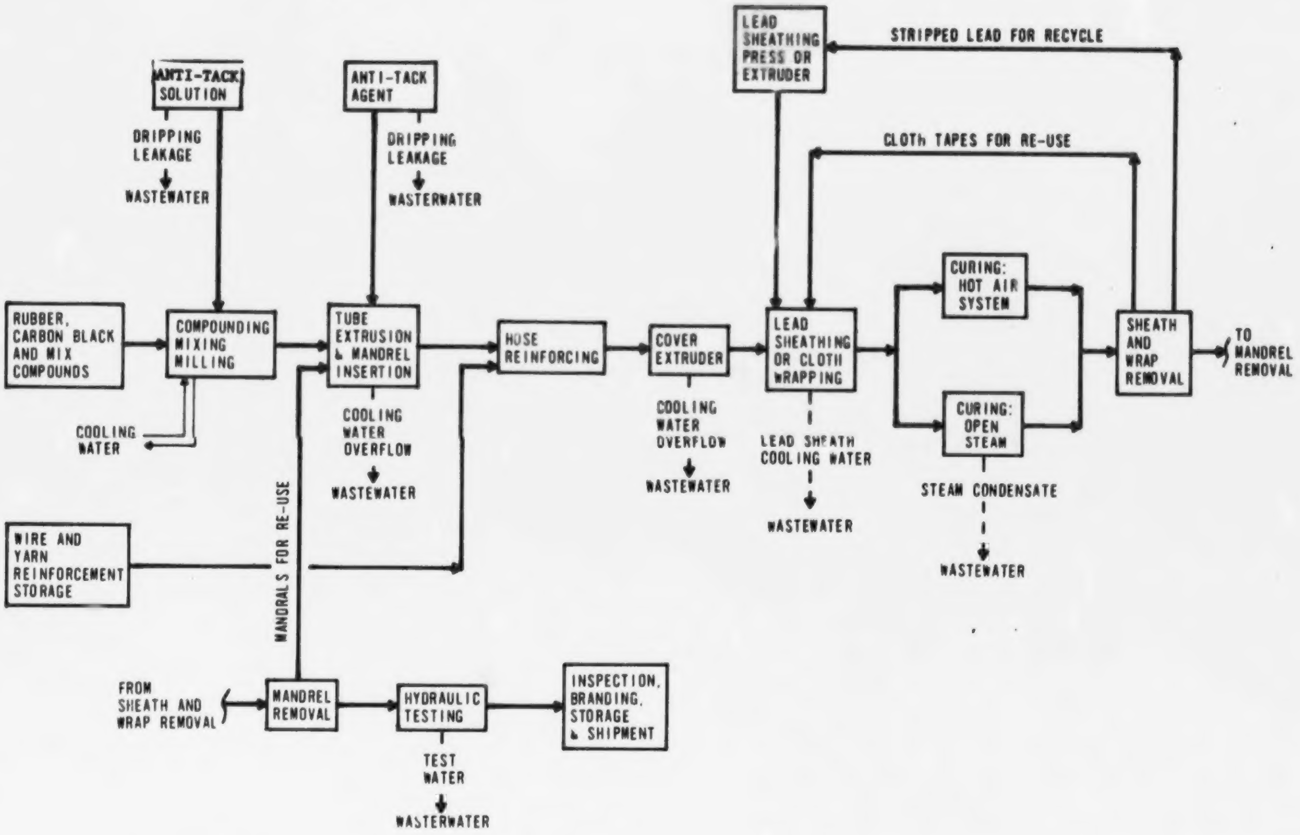

ANTI-TACK SOLUTION
DRIPPING LEAKAGE
WASTEWATER
ANTI-TACK AGENT
DRIPPING LEAKAGE
WASTERWATER
LEAD SHEATHING PRESS OR EXTRUDER
STRIPPED LEAD FOR RECYCLE
CLOTh TAPES FOR RE-USE
CURING: HOT AIR SYSTEM
RUBBER, CARBON BLACK AND MIX COMPOUNDS
COMPOUNDING MIXING MILLING
TUBE EXTRUSION & MANDREL INSERTION
HOSE REINFORCING
COVER EXTRUDER
LEAD SHEATHING OR CLOTH WRAPPING
SHEATH AND WRAP REMOVAL
TO MANDREL REMOVAL
COOLING WATER
COOLING WATER OVERFLOW
WASTEWATER
COOLING WATER OVERFLOW
WASTEWATER
LEAD SHEATH COOLING WATER
WASTEWATER
CURING: OPEN STEAM
STEAM CONDENSATE
WASTEWATER
MANDRALS FOR RE-USE
WIRE AND YARN REINFORCEMENT STORAGE
FROM SHEATH AND WRAP REMOVAL
MANDREL REMOVAL
HYDRAULIC TESTING
TEST WATER
WASTERWATER
INSPECTION, BRANDING, STORAGE & SHIPMENT

FIGURE 3: FLOW DIAGRAM FOR THE PRODUCTION OF TYPICAL HOSE ITEMS (INCLUDING REINFORCED TYPES)

purpose. Three fundamental methods of hose manufacture exist, producing the following types of hose:

1. Machine-wrapped ply hose.
2. Hand built hose.
3. Braided and spiralled hose.

Machine-Wrapped Ply Hose

Wrapped hose consists of a fabric reinforcement wrapped around a rubber tube over which is applied a protective rubber cover. Wrapped hose has been manufactured for approximately 120 years; it was made at first by hand and later by machine. This type of hose is most commonly made in lengths approximating 50 meters (150 feet) and inside diameters (bore) ranging from 5 to 75 millimeters (0.2 to 3 inches).

A seamless rubber tube is formed to the desired diameter and wall thickness by a continuous extrusion process. The tube is then mounted on a rod-like form, termed a mandrel, for the hose making operations using air pressure to enlarge the tube temporarily. Lubricants are generally injected into the tube as it is being formed to prevent the inner surface from sticking to itself, and later in the process to keep the tube from adhering to the mandrel.

The fabric used for reinforcing the hose is received from the textile mill in large rolls. The roll of fabric is impregnated with rubber on both sides in a calendering machine. This process is referred to as frictioning. The frictioned fabric is generally cut on the bias and is cemented together with overlapped seams to form a long strip just wide enough to produce the required number of plies plus an overlap when wrapped around the tube. The hose cover is prepared by working a thin sheet of rubber to the required thickness on a rubber calender. The calendered cover stock is cut to a width which will wrap around the hose carcass with a slight overlap.

The actual making of the hose is done on a special purpose machine known as a "making-machine". The machine consists of three long steel rolls; two of the rolls are in a fixed parallel position in the same horizontal plane. The third or top roll is mounted on lever arms so that it can be raised and lowered. One or more of the rolls is power driven. The mandrel-supported tube is placed in the trough formed by the two bottom rolls of the making machine. One lengthwise edge of the cut fabric is adhered to the tube. The pressure exerted by the top roll when it is brought down in contact with the tube forces the tube and mandrel to rotate as the machine rolls rotate. The fabric is drawn into the machine and wrapped around the tube as the tube rotates. The pressure from the top roll helps to form a compact carcass. The machine operation is repeated for the application of the sheet of cover stock around the hose carcass.

Wrapped ply hose must be kept under pressure during vulcanization to produce a solid, homogeneous construction. The necessary pressure is obtained by means of cotton or nylon wraps.

The wrapped hose is loaded into an open steam autoclave and is vulcanized under controlled conditions of temperature, pressure, and time. The steam condensate is discharged to the plant drains during the vulcanization cycle. The condensate can pick up organic constituents from the hose surface. The autoclave is vented and the hose removed. The cloth wrap is stripped from the vulcanized hose after cooling. The final operation is the removal of the hose from the mandrel, which is accomplished with the aid of compressed air, or water under pressure, injected at one end between the hose tube and mandrel. In cases where pressurized water is used, the spent water is discharged. The water is uncontaminated and could be recycled.

Hand-Built Hose

The term hand-built hose applies to two general types of hose, non-wire reinforced and wire reinforced, which are made by hand on a steel mandrel. The hose is made by hand when it is too large in diameter, too long to fit in the three-roll making-machine, or when the hose is made with special ends. The hand method is also used frequently when the fabric reinforcement must be applied one ply at a time. The mandrel is mounted on a series of double roller stands, and one end of the mandrel is held in the jaws of a power-driven chuck in order to rotate the mandrel during the making operations.

The tube for hose up to 100 millimeters (4 inches) inside diameter is usually extruded and mounted on a mandrel by methods already described under machine-made hose. The tube for larger hose is formed by wrapping calendered tube stock around the mandrel with an overlapping seam running the length of the tube.

Non-wire reinforced hand-built hose is made of the same components as machine-wrapped ply hose; i.e., a rubber tube, plies of fabric reinforcement wrapped around the tube, and a rubber cover.

The frictioned and cut fabric is applied to the tube by hand and rolled down progressively as the mandrel is turned.

A calendered sheet of cover stock is applied to the carcass to complete the construction of the hose. The hose is cross-wrapped with one or more layers of nylon or cotton tape using a power chuck before vulcanization in an open steam autoclave. The wrapping tape is removed after vulcanization and the mandrel is withdrawn from the hose.

Wire reinforced hand-built hose, as the name indicates, has wire added to the reinforcement component of the construction. The wire may be present to prevent the hose from collapsing in suction service, to prevent kinking of pressure hose which must be curved in a small radius loop, or to obtain the strength necessary for high pressure service.

The wire in suction hose is located underneath the main plies of fabric reinforcement to provide rib support against the external pressure. Hose designed for a combination of suction and pressure is made with the wire placed approximately midway in the plies of the fabric. In pressure hose, the wire is positioned over the main plies of fabric to provide hoop strength against high internal pressure. The wire is present in most wire reinforced hose in the form of a closely spaced helix or spring which opposes inward or outward radial stresses but does not add any significant strength to the hose in the axial direction. When high strength is needed in both axial and radial directions, the hose is built with two or more even numbers of layers of wire. Each layer is composed of many strands of solid round wire or wire cable applied over the fabric reinforcement. The wire lays on the hose in a spiral forming an angle greater than 45° with the axis of the hose. The direction of the wire spiral is reversed with each layer of wire for balanced strength. The wire is applied to the hose by hand or by a simple machine using a power-driven chuck to rotate the mandrel and hose. In all other operations, wire reinforced hand-built hose is made in the same manner as non-wire reinforced hand-built hose.

Braided and Spiralled Hose

The term braided hose identifies a type of hose construction and method of manufacture in which the strands of reinforcement are interlaced or interwoven in addition to spiralling around the tube. Braided hose is produced in size ranging from 5 to 200 millimeters (0.2 to 8 inches) internal diameter. A variety of methods is available for manufacture. Factors such as internal diameter, length, burst strength, production rate, and cost dictate to a large extent how the hose is made.

Manufacturing commences with the extrusion of a tube supported on a flexible mandrel or a non-supported tube in lengths up to 50 meters (165 feet) or in continuous lengths. Non-supported tube must be firm enough in the unvulcanized state to resist deformation and stretching under normal processing conditions. A high percentage of braided hose is made with a non-supported tube. When the tube is too thin or too soft to withstand subsequent processing or when the internal diameter must be kept within a narrow range, it is supported on a flexible mandrel. The mandrel is at least as long as the hose to be made, has a round cross-section, and can be coiled in a small diameter. It is made of rubber or plastic material and may have a wire core to prevent stretching.

The tube, stored on a circular tray or a reel after extrusion, is moved to the braider where the reinforcement is applied. The tube is drawn through the center of the machine while the braid is forming on the tube surface. The braid formation is brought about by yarn or wire carriers weaving in and out on a circular track not unlike the movements and result of the Maypole dance. The speed of the carriers on the circular track is kept at maximum. The braid angle can be adjusted by changing the surface speed of the overhead take-off drum or capstan.

After the hose has been braided, it is normally passed through a cross-head extruder, where an outer seamless rubber cover is applied. At this stage, the hose is still in the long length either coiled on a circular tray or wound on a reel, and consists of an unconsolidated construction of a tube, braid or braids, and a cover.

The final production operation in hose manufacture is vulcanization. The lead sheath process is so eminently suited for the vulcanization of braided hose that only insignificant quantities are vulcanized by any other method. The lead casing may be formed by means of a lead press or a lead extruder. (The lead press deforms solid lead into a continuous sheath whereas the lead extruder forms molten lead into a continuous casing.) In both techniques, the casing or sheath is actually formed around the hose as it passes through the press or extruder. In the case of non-supported hose, the lead-sheathed hose is filled with water under pressure, wound on reels, and loaded into an open steam pressure vessel. The internal pressure is maintained during the vulcanization cycle to force the hose against the lead casing. The water is drained from the hose after vulcanization and the lead casing is stripped from the hose. The lead goes back to a melting pot and is reused.

In the case of supported tube hose, the application of the lead sheath squeezes the flexible hose down on the mandrel and places the hose under slight initial pressure. However, most of the internal pressure comes from the hose's trying to expand as the temperature is increased during vulcanization; yet it is closely confined between the lead casing and the flexible mandrel. After vulcanization, the lead casing is removed in the same manner as for unsupported hose. One end of the hose is connected to a high pressure hydraulic system and the flexible mandrel is forced out of the hose. Braided hose can also be vulcanized in steel molds which are constructed in two sections. The unvulcanized hose is laid in the bottom half of the cavity and the mold closed. The mold is steam heated and the hose is subjected to internal air pressure causing it to expand, forcing it against the inside wall of the mold.

A third method of vulcanizing braided hose, which is only used on a very limited scale, is known as non-mold cure. The hose, coiled one or two layers deep on a metal pan, is exposed to open steam under pressure in an autoclave.

The term "spiralled hose" describes how the reinforcement in the form of strands of yarn or wire is applied by machine with the strands drawn from supply spools or packages. This type of hose has all of the wire or textile strands of each reinforcement layer aligned in one direction and parallel to each other. In other words, the clockwise strands are not interwoven with the counter-clockwise strands. At least two layers of reinforcement are required with the layers spiralled in alternating directions to form a balanced construction.

The reaction of spiralled hose constructions to internal pressure is exactly the same as that of braided hose. The relative simplicity of both wire and yarn spiralling machines with the carriers fixed on a rotating plate makes it possible to run at higher speeds with a corresponding increase in the rate of production compared to braided hose.

Spiralled hose is not manufactured in as broad a size range as braided hose. Spiralled hose internal diameters generally range from 5 to 50 millimeters (0.2 to 2 inches).

The processing equipment used in the operations performed before and after the application of the reinforcement are the same as those described above for braided hose.

The hose is generally vulcanized by the lead sheathing method. In some cases, the non-mold or the steel-mold vulcanization techniques are used. In addition, hose on rigid mandrels can also be wrapped with a curing tape and vulcanized in an open steam pressure vessel.

Coated Materials

Materials coated with rubber compounds are generally an essential ingredient in the manufacture of fabricated products. Many plants, starting with a rubber compounding operation, coat the fabric material and ship the coated fabric to another plant where it is fabricated into the finished article. Other plants, however, have an integrated facility where the rubber stock is compounded, the fabric is coated, and finally the article is built and vulcanized; all in the one plant.

Rubber coated materials generally consist of woven or nonwoven fabrics to which a rubber compound or composition has been applied either by impregnation of the fabric or by application to one or both sides. Synthetic rubber materials such as acrylic rubber, butadiene-acrylonitrile, butadiene-styrene, chloroprene, chlorosulphonated polyethylene, fluorinated polymeric compositions, polyisobutylene, polysulfide and silicone polymers are used where particular physical properties such as water and solvent resistance, gas impermeability, flame resistance, surface-release characteristics, abrasion resistance, and good aging properties are required.

Rubber-coated fabrics are generally used for industrial applications where their characteristic odor and color limitations are not objectionable. Such products are frequently specified for usage requiring low-temperature flexibility. Typical uses for rubber-coated textiles include service raincoats, ballon bags, diaphragms, gaskets, inflatable life rafts, pontoons, etc. Rubber coatings are generally applied by calendering techniques.

Rubber-coated cotton sheeting is used to produce friction tape, raincoats, gasketing, and diaphragms. Rubberized knit cotton fabric is used to manufacture rubber overshoes, boots, and diaphragms. Rubber-coated duck and canvas is fabricated into pontoons, lifeboats, and tarpaulins. The origin of coated fabrics has been traced to the application of preservative resins on Egyptian mummy wrappings. More recent use of coated fabrics during the early nineteenth century evolved from the linseed oilcoated fabrics (oilskins) used by seafarers and the rubber-coated protective garments developed by Charles Macintosh, still known as macintoshes. These early products were accompanied by objectionable odors and poor aging properties resulting either in tackiness or in embrittlement. Improvement in rubber coatings followed Goodyear's discovery of the vulcanization technique in 1839.

In early usage of coated fabrics, the base material was required to give strength and tear resistance to the finished product. In such constructions heavy cotton sheetings, drill weaves, sateens, broken twills, and canvas were required to give proper service. The fabric is often treated before coating. Fabric treatments can include desizing to produce pliability, surface shearing or brushing to remove knots and flaws, dyeing to match the coating, matting to improve softness or coating adhesion, and flame proofing.

Most recent constructions of coated fabrics employ knitted textiles or non-woven textile webs to achieve maximum softness and tear resistance these fabrics depend on the toughness of the coating to furnish abrasion resistance and long service life. The use of very lightweight and very strong synthetic fiber fabrics has permitted design of lightweight air-holding products for inflated structures and similar uses. Saturated nonwoven cotton textiles have found extensive applications as garment linings and interfacings.

Before the coating process, the rubber stock is compounded from basic rubber ingredients such as rubber crumb, extenders, pigments, accelerators, and anti-oxidants. The waste waters arising in a typical compounding area result from leaks and spillage and the principal contaminants are oil and grease, and suspended solids. The fabric to be coated is received from the textile mill either already dipped in latex or the dipping can be carried out in the rubber coating plant. If a fabric dipping operation is employed, latex spillage and washdown are potential waste water sources.

Rubber coating is performed in either three or four-roll calenders. The compounded rubber stock is generally prepared for the calender on a warmup mill. The three-roll calender applies the coat to one side of the fabric and the four-roll calender coats both sides of the fabric. The top roll of the three-roll calender or the bottom and offset rolls of the four-roll calender are run at a different speed to the center roll, usually two-thirds as fast, to friction the rubber coating onto the fabric.

Rubber-coated fabrics need to be cured at elevated temperatures for periods of time varying from ten minutes to several hours. The curing ovens can be 30 feet high and hundreds of feet long, or 6-8 feet in height and 8-20 feet in length for products requiring a shorter curing cycle. The principal requirement for the ovens is that of uniform temperature distribution to obtain uniform product quality. After curing the coated fabric is cooled and rolled.

Fabricated products such as rainwear, rafts and pontoons are built using dies or jigs to cut the coated material and rubber cements to join the various sections. In general the building areas are dry and no waste waters should arise. In the event of a spillage of rubber cement, the spill or leak would most effectively be wiped away.

The types and characteristics of waste waters produced by a rubber coating or fabrication manufacturing facility are similar to those of a rubber footwear facility and are presented in Table 6.

Rubber Footwear

It can be seen from Table 5 that rubber footwear (SIC 3021) is the second largest product area of the general fabricated products group, and that canvas footwear is the major type of rubber footwear manufactured.

The process description presented below pertains to canvas shoe production which utilizes all the major processing technologies commonly found in the manufacture of general fabricated products. A schematic flow diagram for a typical canvas shoe production facility is shown in Figure 4.

The various rubber stocks consumed in a canvas shoe plant are compounded in Banbury mixers or compounding roll mills and then sheeted out. The sheeted rubber is dipped in a anti-tack solution to prevent sticking during storage.

Plant Unit or Area	Source	Nature and Origin of Waste Water Contaminants
Oil Storage	Spills and leaks	Oil pick-up by storm run-off.
Latex Storage	Spills, leakage, washdown, and cleanout waters	Dissolved organics, suspended and dissolved solids.
Compounding	Washdown, spills, leaks and discharges from wet air pollution control equipment	Solids from **anti-tack dip tank.** Oil and water leaks from mixers and mills. Solids from wet air pollution control equipment discharges.
Pre-form Extrusion and Preparation	Rinse waters, spills and leaks	Rubber fines in lubricant and rinse water anti-tack agents in cooling tank overflows, oil from machinery.
Ply Formation	Spills, leaks and washdown	Dissolved organics, suspended and dissolved solids
Shoe Building	Spills, leaks and washdown	Dissolved organics, suspended and dissolved solids.
Curing	Discharges from air pollution equipment	Ammonia used in curing.

Table 6 - Process-Associated Waste Water Sources from Rubber Footwear Production

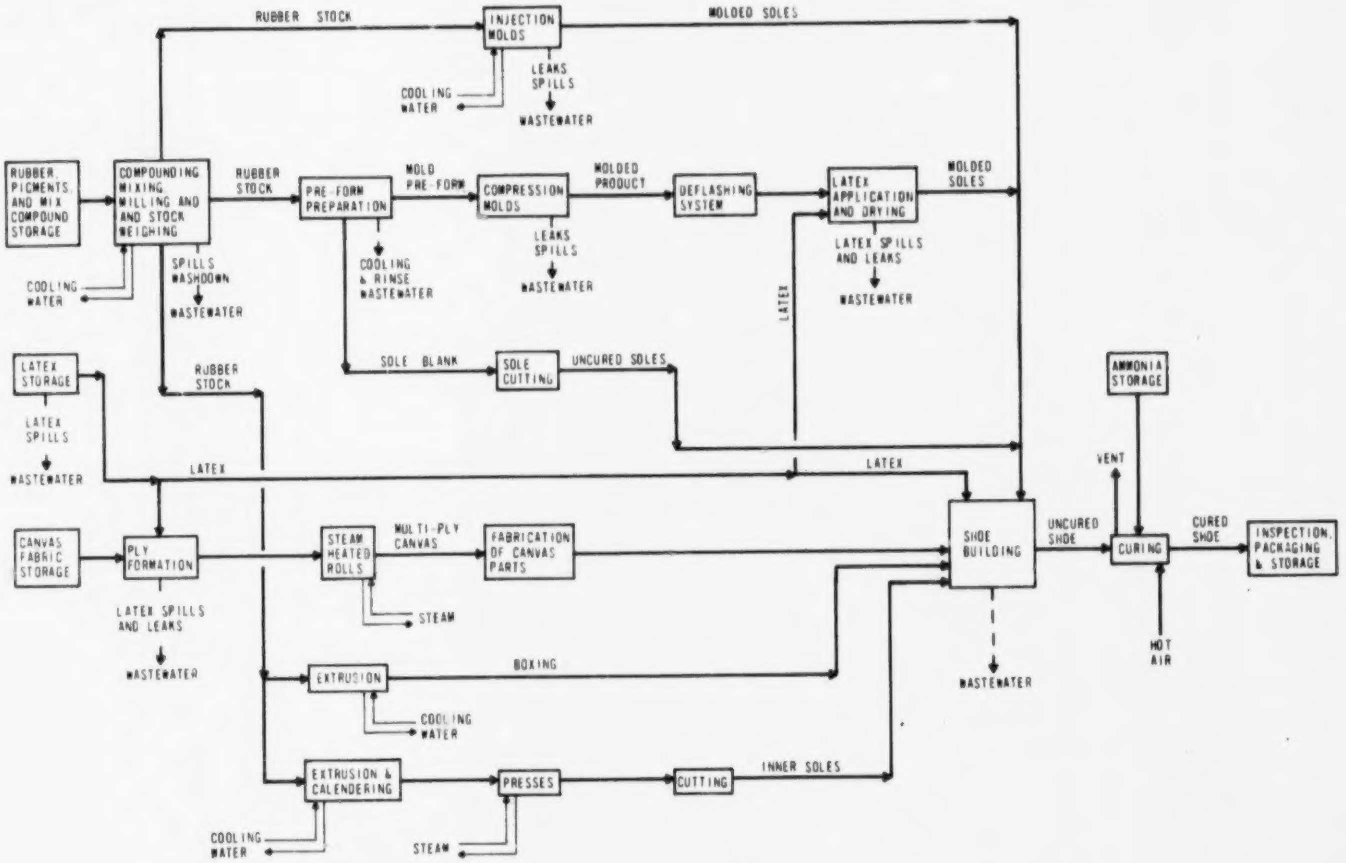

RUBBER STOCK
INJECTION MOLDS
MOLDED SOLES
COOLING WATER
LEAKS SPILLS
WASTEWATER
RUBBER, PIGMENTS, AND MIX COMPOUND STORAGE
COMPOUNDING MIXING MILLING AND AND STOCK WEIGHING
RUBBER STOCK
PRE-FORM PREPARATION
MOLD PRE-FORM
COMPRESSION MOLDS
MOLDED PRODUCT
DEFLASHING SYSTEM
LATEX APPLICATION AND DRYING
MOLDED SOLES
COOLING WATER
SPILLS WASHDOWN
WASTEWATER
COOLING & RINSE WASTEWATER
LEAKS SPILLS
WASTEWATER
LATEX
LATEX SPILLS AND LEAKS
WASTEWATER
LATEX STORAGE
RUBBER STOCK
SOLE BLANK
SOLE CUTTING
UNCURED SOLES
AMMONIA STORAGE
LATEX SPILLS
WASTEWATER
LATEX
LATEX
VENT
CANVAS FABRIC STORAGE
PLY FORMATION
STEAM HEATED ROLLS
MULTI-PLY CANVAS
FABRICATION OF CANVAS PARTS
SHOE BUILDING
UNCURED SHOE
CURING
CURED SHOE
INSPECTION, PACKAGING & STORAGE
STEAM
LATEX SPILLS AND LEAKS
WASTEWATER
HOT AIR
EXTRUSION
BOXING
WASTEWATER
COOLING WATER
EXTRUSION & CALENDERING
PRESSES
CUTTING
INNER SOLES
COOLING WATER
STEAM

FIGURE 4: FLOW DIAGRAM FOR THE PRODUCTION OF TYPICAL CANVAS FOOTWEAR ITEMS

The canvas shoe is built from four major components: soles, canvas uppers, boxing, and innersoles. These components are made separately by varying operations before being brought together in the fabrication operation.

The soles are generally molded using injection, compression, and transfer molding techniques. All molding processes can produce oil spills and leaks; however, compression and transfer molding equipment generally produce more oil spillage than the injection molding machines.

The molded soles are deflashed, usually in a buffing machine, before coating with latex adhesive. The latex coating is dried in an oven.

The canvas components for footwear are made from two or three-ply fabric. The fabric is received at the plant as single sheets. Latex is applied to the plies, which are pulled together and passed over a heated drum. The sheets are stacked and the multilayer canvas is stamped to shape. The different canvas components making up the shoe uppers are stitched together on sewing machines. The boxing, or edging, which protects the join between the sole and the canvas uppers is extruded as a long strip from rubber stock.

The innersole is extruded in a flat sheet from a special rubber stock. The extruded sheet is passed through heated presses. Blowing agents, such as sodium bicarbonate and azodicarbon amide, which are mixed into the rubber stock in the compounding area, decompose and release gases which blow the extruded sheet into cellular sponge. The innersoles are then stamped out of the cellular sheet.

The shoe is built from the various components on a last. Firstly the canvas upper is cemented at its edges, and placed over the last. The innersole is attached to bottom of the last. The outer sole, toe and heel pieces, and boxing are placed on the shoe using latex as an adhesive. The complete, uncured shoe is usually inspected and placed in an autoclave to cure.

The autoclave is air heated. Anhydrous ammonia is injected into the autoclave to complete the cure. Curing with ammonia produces a good surface texture on the rubber and eliminates the residual tackiness associated with rubber that is cured conventionally. Some shoes are cured without ammonia. This is done where the tackiness of the product is not very important or where the compounding recipe can be modified to eliminate the tackiness often associated with regular air curing. Steam is not used for curing because in many cases the steam would stain the canvas parts of the shoe. The curing cycle can last about one hour and approximately two to five pounds of ammonia are used for every thousand pairs of shoes cured. At the end of the curing cycle the ammonia/air mixture is vented to the atmosphere. No air pollution problems or requirements appear to be associated with this practice and air pollution control devices are not envisaged.

As described above, latex is used in several applications as an adhesive. The latex is received at the footwear plant either in bulk via tank truck or in 55-gallon drums. Spills, leaks, and cleanout waste waters, laden in uncoagulated latex solids, are frequently produced.

The nature of the waste waters produced by a typical footwear production facility are listed in Table 6.

Tire Retreading

Tire retreading is an industry dominated by independents. Approximately 5,000 retreading shops or plants are currently registered with the Federal Department of Transportation and the number of tires retreaded by the industry as a whole approaches 32 million each year. There are a few large retreading plants which are operated by the major tire companies; in most aspects these are very comparable to a plant manufacturing new tires. An average retreading requires approximately 10 pounds of rubber per passenger tire and 35 pounds per truck tire. Very few tire retreading facilities compound their own rubber stock. Those that do mix stock will have potential waste water contamination problems with oil from machinery and suspended solids from anti-tack dip equipment and wet scrubbing devices, although well-designed curbing should contain such spillages. After compounding, the stock is extruded to produce the camelback tread rubber. The extruded camelback is usually passed through a water cooling tank which has an overflow. However this cooling water overflow is usually not contaminated with oil and grease and suspended solids, and should not require treatment.

The majority of retreading shops purchase the rubber stock from an outside supplier in the form of camelback tread or extruded rubber. The worn tire is first visually inspected to ascertain its suitability of retreading. Those failing the inspection are removed from the retreading shop as solid waste. The satisfactory worn tire is buffed with a grinding wheel to remove the old, worn tread rubber. Rubber buffings collected in the buffing area are solid waste and are periodically containerized and removed from the plant. Few plants have air pollution control devices to remove the fine buffings from the air.

The buffed casing is coated with rubber cement and the camelback tread or extruded rubber is applied around the tire and cut to length. The tire with tread rubber is placed in the curing mold and the mold is closed. Curing molds are either steam heated with the steam condensate recycled to the boiler, or heated with electricity.

After curing, the tire is removed from the mold. The rubber flash is buffed off the tire before it is inspected and shipped.

The process waste water types generated in a typical retreading shop are minor and arise from spillage and washdowns. These waste water types are adequately covered by those waste waters listed in Table 2 for general molded products. The contaminants of these waste waters are oil and suspended solids. However, most plants do not have any process waste waters at all, and the waste water discharges are limited to boiler blowdown, cooling water, and sanitary waste waters.

Reclaimed Rubber Production

The quantity of scrap rubber being reclaimed and re-used and the number of rubber reclaiming plants operati[illegible] in the United States have both steadily declined over the past de[illegible] This decline has occurred despite increased production and use of rubber products. As a percent of new rubber produced, reclaimed rubber fell from 19 percent in 1958 to 10 percent in 1968. Some of this reduction is probably due to development of new rubbers not compatible with reclaimed rubber, but, undoubtedly, the major decreases were caused by cost, quality, and environmental reasons. Table 7 indicates the usage of reclaimed rubber during the 1960's and it can be seen that substantial reductions have occurred in some applications. Competitive materials, such as rugs and colored plastics, have reduced usage in automotive mats and mechanical parts from 105 million pounds in 1960 to approximately 55 million pounds. Similar reductions are noted for other mechanical goods, hose, shoe heels and soles, and hard rubber products.

Reclaimed rubber is the product resulting from the treatment of ground scrap tires, tubes, and miscellaneous waste rubber articles with heat and chemical agents whereby a substantial devulcanization or regeneration of the rubber compound to its original plastic state is effected, thus permitting the product to be reprocessed, compounded, and revulcanized. The term "devulcanization" which is frequently associated with reclaiming is a misnomer. Actually all the commercial reclaiming processes employed are based on depolymerization of the rubbers. This depolymerization can occur either by promoting thermal scission or breaking of the polymer chain or by oxidation at points other than at cross-linking sites. Some scission of the existing crosslinks may also occur.

There are two fundamental factors which determine the type of reclaim. The first, and the most important, is the type of scrap from which the reclaim is made. The second is the process by which the scrap is reclaimed.

	Million Pounds of Product			
	1960	1967	1968	1969
Automotive Products				
Tires, Inner Tubes, and Tire Repair Material	380.6	379.5	415.3	396.0
Automobile Mats and Mechanical Parts	104.8	55.8	57.6	55.3
Hose and Belt	36.1	26.2	24.9	31.8
Mechanical Goods	52.6	31.8	23.5	32.9
Non-Automotive Products				
Cements and Dispersions	15.7	16.4	18.4	19.7
Heels and Soles	17.0	8.7	11.4	5.6
Hard Rubber	26.2	14.3	7.4	6.9
Rubber Surface	--	4.9	5.1	3.3
Other	22.9	11.0	12.1	8.3
Total	655.9	548.6	575.7	559.6

Source: "Rubber Reuse and Solid Waste Management" (Part I), R.J. Pettigrew and F.H. Roninger; published by the U.S. Environmental Protection Agency (1971).

Table 7 - Consumption of Reclaimed Rubber by Product

By far the most important source of raw material is tire scrap. The supply is plentiful and well distributed so that it is relatively easy to collect. The quality of rubber in tires is high, giving an unusually high percentage of rubber hydrocarbon at low cost. The whole tire creates problems due to the tire-cord fiber contained in the carcass portion. This fiber has to be removed either by mechanical means or by chemical methods such as those used in the digester process.

Three basic techniques are used at existing plants to produce reclaimed rubber: the digester process, the pan process, and the mechanical process. A generalized material flow diagram for the three process is shown in Figure 5. Broadly, the reclaiming process can be divided into three major parts, two of which are mostly mechanical and the other predominantly chemical. The rubber scrap is first separated and ground, then given heat treatment for depolymerization, and finally processed by intensive friction milling. All three processes employ similar rubber-scrap separation and size-reduction methods. They differ in the depolymerization and the final processing steps.

Rubber Separation and Size Reduction

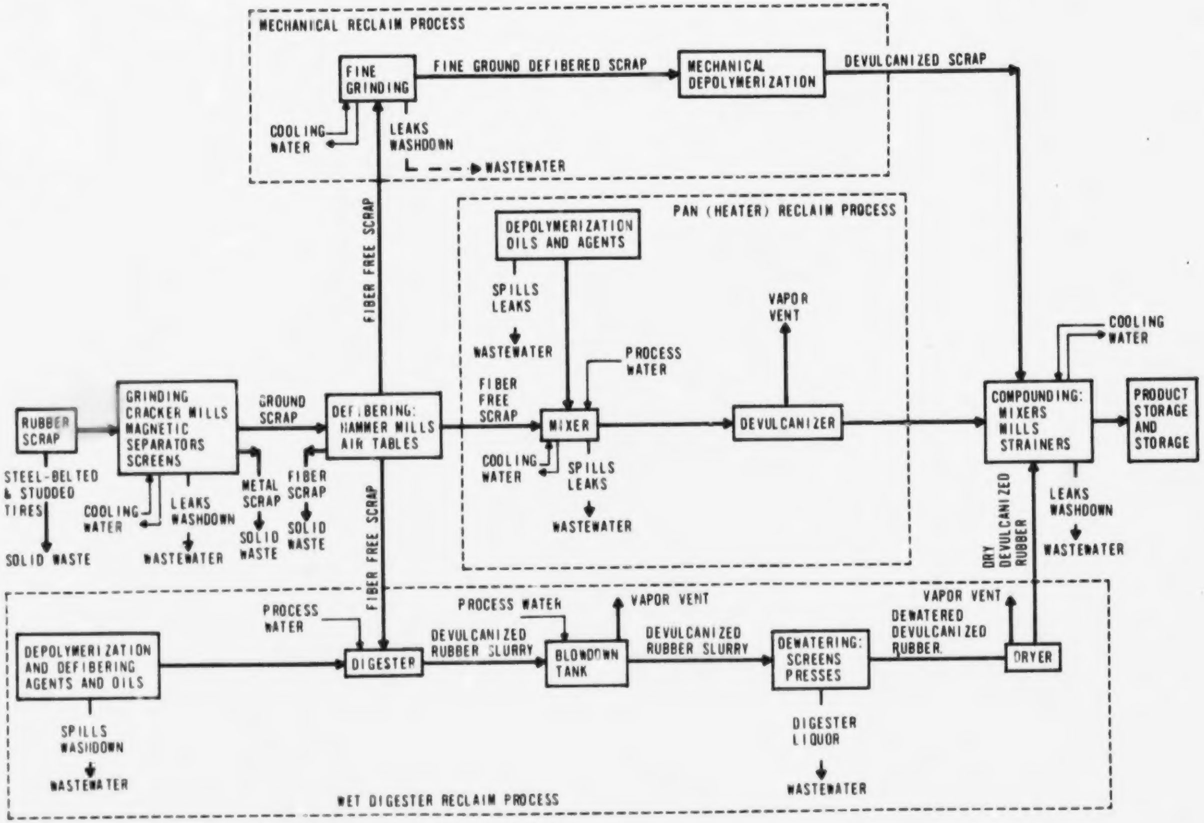
The rubber scrap is first sorted, and then reduced by mechanical chopping or cracking on a very heavy cracker mill to a suitable size for the particular depolymerization step being used. A cracker mill consists of two horizontal heavy steel rolls revolving at different speeds. The roll surfaces are corrugated, giving a scissor-cutting action. In the case of tires, the wire beads are broken in the cracker mill and removed with magnetic separators along with any other ferrous material which may have been picked up during their use. The cracked ground stock is conveyed to a vibrating screen of a given mesh size. The oversized material is returned to the crackers for further grinding. The stock which passes through the screen is conveyed to storage bins to await use in the depolymerization process.

Most reclaiming plants require fiber-free scrap in the depolymerization process. A series of screens, air separators, and sizing equipment are used to remove fiber from ground rubber scrap. First the rubber scrap is passed through hammer mills and beaters which removes fiber from the rubber. This screened mass then goes to an air-flotation table where the final separation of fiber and rubber takes place. After passing through magnetic separators, the rubber crumb which results goes to storage bins.

Rubber scrap separation and size reduction is followed by the appropriate depolymerization process.

Depolymerization

Digester Process


MECHANICAL RECLAIM PROCESS
FINE GRINDING
FINE GROUND DEFIBERED SCRAP
MECHANICAL DEPOLYMERIZATION
DEVULCANIZED SCRAP
COOLING WATER
LEAKS WASHDOWN
WASTEWATER
FIBER FREE SCRAP
PAN (HEATER) RECLAIM PROCESS
DEPOLYMERIZATION OILS AND AGENTS
SPILLS LEAKS
WASTEWATER
VAPOR VENT
PROCESS WATER
COOLING WATER
RUBBER SCRAP
GRINDING CRACKER MILLS MAGNETIC SEPARATORS SCREENS
GROUND SCRAP
DEFIBERING: HAMMER MILLS AIR TABLES
FIBER FREE SCRAP
MIXER
DEVULCANIZER
COMPOUNDING: MIXERS MILLS STRAINERS
PRODUCT STORAGE AND STORAGE
STEEL-BELTED & STUDDED TIRES
SOLID WASTE
COOLING WATER
LEAKS WASHDOWN
WASTEWATER
METAL SCRAP
SOLID WASTE
FIBER SCRAP
SOLID WASTE
COOLING WATER
SPILLS LEAKS
WASTEWATER
DRY DEVULCANIZED RUBBER
LEAKS WASHDOWN
WASTEWATER
FIBER FREE SCRAP
PROCESS WATER
PROCESS WATER
VAPOR VENT
VAPOR VENT
DEPOLYMERIZATION AND DEFIBERING AGENTS AND OILS
DIGESTER
DEVULCANIZED RUBBER SLURRY
BLOWDOWN TANK
DEVULCANIZED RUBBER SLURRY
DEWATERING: SCREENS PRESSES
DEWATERED DEVULCANIZED RUBBER
DRYER
SPILLS WASHDOWN
WASTEWATER
DIGESTER LIQUOR
WASTEWATER
WET DIGESTER RECLAIM PROCESS

NOTE: SOME RECLAIMING FACILITIES OPERATE MORE THAN ONE TYPE OF PROCESS

FIGURE 5: FLOW DIAGRAM OF TYPICAL MECHANICAL, PAN (HEATER), AND WET DIGESTER RECLAIM PROCESSES

The digester process consists of placing the ground scrap, water, and reclaiming agents into a steam-jacketed agitator-equipped autoclave (digester). The batch is then cocked for 5 to 24 hours at 370-405°F. During this time the rubber becomes partially depolymerized, and attains the consistency of soft granules. Reclaiming agents that are used include petroleum and coal tar-base oils and resins, as well as various chemical softeners, such as phenol alkyl sulfides and disulfides, thiols (mercaptans), and amino compounds. Reclaiming agents or oils are used to speed the depolymerization, to impart desirable processing properties. Natural rubber can be reclaimed in the absence of any reclaiming agents. SBR types, however, require the assistance of these reclaiming agents or catalysts to produce a reclaim. The reclaiming agents generally function by catalyzing the oxidative breakdown of the polymer chain and oxidatively disrupting sulfur crosslinks.

Rubber scrap which has not been defibered mechanically requires chemical degradation of the fibers in the digestion process. Defibering agents, such as caustic soda or the chlorides of zinc and calcium, and plasticizing oils are added to the digester to complete the charge. The fiber from tires and other rubber scrap products is hydrolyzed and goes into solution. The presence of synthetic rubber such as SBR in the tire scrap necessitates the use of the metallic chlorides in place of the caustic soda since the caustic solution produces a heat-hardening effect with SBR instead of softening.

At the end of the digestion period the contents of the digester are blown down under internal pressure into a blowdown tank. Water is added to the soupy mass to facilitate the subsequent washing operations. After thorough agitation, the mixture is discharged onto continuous vibrating screens where a series of spray nozzle showers wash the rubber free from the digester liquor.

The washed rubber, which is in the form of a slurry, is then passed through a dewatering press which forces out much of the occluded water. The dewatered rubber is dried in a hot-oven or tray dryer prior to further processing.

In cases where chemical defibering is carried out in the digestion process, the rubber has to be washed free from the decomposed fiber as well as the digestion liquor. This washing procedure generates waste water which can be alkaline or laden with metal chlorides and fine sludge-like particles of hydrolyzed fiber and rubber. Chemical defibering and the subsequent washing process create an effluent problem. At present, mechanical fiber separation is used to reduce the waste water problem inherent in the digester process.

Pan Process

The finely-cracked scrap, which is usually free from fiber, is reduced to a finer particle size by grinding on smooth steel rolls. The finely-ground scrap is blended in an open mixer with the correct amount of reclaiming oils and is then placed in open pans which are stacked on a carriage and placed in a large horizontal heater. The heater is a single-shell pressure vessel into which live steam is passed. Depolymerization is carried out at about 365°F for 2 to 18 hours. After this treatment the heater is vented, the pans discharged, and the cakes of rubber sent on for further processing. Since the condensate from this operation is highly contaminated with gums, resins, etc., it cannot be returned to the boilers and, therefore, must be treated as a waste. This waste is similar in composition to the digester alkali and chloride wastes.

The pan process is relatively inexpensive because the equipment is simple, and the washing and drying steps are eliminated. The supply of cheap fiber-free scrap rubber can be a limiting factor in the operation of the pan reclaiming process.

Mechanical Process

The mechanical reclaiming process, unlike the other two preceding processes, is continuous. The fine ground, fabric-free rubber scrap is fed continuously into a high-temperature, high-shear machine. The machine is a horizontal cylinder containing a screw for forcing and working the material along the chamber wall at 350 to 400°F in the presence of reclaiming agents and catalysts for depolymerization. The rate of depolymerization is controlled by the speed of screw while the compression and temperature is maintained constant. The discharged reclaimed rubber needs no drying and is ready for further processing.

Final Processing

The final stage of the reclaiming operation, namely milling, first involves the mixing and blending of the material from any of the various depolymerization processes in a Banbury internal mixer with small amounts of reinforcing materials such as clay, carbon black, and softeners. This aids in smoothing dried stock and attaining uniformity. The reclaim is then given a preliminary refining on a short two-roll mill having a high-friction ratio between the roll surfaces. The sheet thickness after the first refiner pass is about 0.01 inch. The reclaim is then strained to remove foreign matter before going to the final thickness of 0.002 to 0.005 inch. The strainer is an extruder which contains a wire mesh screen held between two strong perforated steel plates in the head of the machine. The strainer not only removes foreign matter, but also plasticizes and blends the reclaim.

Each reclaimer may complete his reclaiming operations in either of two ways - by sending his product to the customer in the form of slabs stacked on pallets or bales. Slabbed reclaim is made on a mill and the discharged sheet is wrapped on a rotating drum of a specified diameter, until the proper thickness is obtained. The wrapped layers or sheet are then cut off the drums, forming a solid slab of a certain length, width, and weight. The slabs are then dusted with talc to prevent sticking to each other, tested, and shipped to the customer. Baled reclaim, is also made on a mill, except the thin milled sheet is conveyed to a baler, where the rubber is compacted to form a bale. The bale is then encased in a bag, stacked on a pallet, tested, and sent to the customer.

The effluent waste waters occurring during the various reclaiming processes are identified in Table 8.

Manufacture of General Latex-Based Products

To manufacture sundry rubber goods from latex compounds, it is necessary to convert the compounds into solids of the desired form. Latex compounds are generally stabilized by the latex producer before shipping to the rubber goods manufacturing facility. Here, the stabilized latex compound is transformed into the final rubber good.

Prior to forming the rubber goods, the latex is compounded (mixed) with various ingredients, such as antioxidants, in accordance with a specific recipe. The mixing of latex compounds is a simple operation consisting of weighing out the proper amounts of the various solutions and emulsions required, and then stirring these materials into the latex, usually in a large tank equipped with a mechanical agitator. In some cases, such as the compounding of latex for foam sponge, some of the ingredients must be added just prior to or during the foaming operation, and in these cases complicated automatic proportioning equipment is sometimes used.

Several types of rubber goods are fabricated from latex mixtures. The basic manufacturing processes and their waste water generations for these product types are described below. The major classes of latex-based goods are dipped goods, such as finger cots and surgical gloves, and foam-backing materials. Table 9 lists the value of 1967 U.S. shipments of the principal rubber products fabricated from latex mixes. It is believed that many of the foam products listed in Table 9 are no longer made and have been replaced by chemically blown sponge or urethane-type foams. As discussed earlier, it is difficult to obtain more up-to-date production figures for these items in terms of product or raw material weights.

Latex-Based Dipped Goods

There are two principal techniques used in the manufacture of dipped rubber goods. One is the straight-dip method employed in the production of very thin-walled dipped goods from which water can

Plant Unit or Area	Source	Nature and Origin of Waste Water Contaminants
Wet Digester Reclaim Process		
Grinding	Washdown, spills, leaks	Bearing oil from machine drives Oil from seals on milling equipment.
Depolymerization, Defibering and Oil Storage	Spills, runoff	Oil, solids, caustic and organics.
Blowdown Tank	Air pollution equipment	Oils and organics.
Dewatering	Digester liquor	Oil, solids, caustic and organics from spent depolymerization and defibering agents and excess oil. High concentrations of fibrous material removed from tires.
Dryers	Air pollution equipment	Oils and organics.
Compounding	Washdown, spills, leaks, air pollution equipment	Bearing oil from machine drives. Oils from seals on milling equipment. Solids from anti-tack dip tanks. Solids from air pollution equipment.
Pan (Heater) Reclaim Process		
Grinding	Washdown, spills, leaks	Bearing oil from machine drives. Oil from seals on milling equipment.
Depolymerization Agent and Oil Storage	Spills, runoff	Oil, solids, caustic and organics.
Devulcanizer	Air pollution equipment	Oil and organics.
Compounding	Washdown, spills, leaks, air pollution equipment	Bearing oil from machine drives. Oils from seals on milling equipment. Solids from anti-tack dip tanks. Solids from air pollution equipment.

Table 8: Process-Associated Waste Water Sources from Rubber Reclaiming

Product Type	Value (million dollars)
Dipped Goods	
Household gloves	11.1
Surgical gloves	20.0
Prophylactics	16.4
Balloons (Toy and Advertising)	10.3
Thread (bare rubber)	25.2
Latex Foam	
Automotive Seating	19.3
Upholstery	39.9
Mattresses and Pillows	17.8
Carpet and Rug Cushions	24.2
Other Latex Foam Products[1]	59.3
Total	243.5

[1] Includes hospital padding and topper pads.

SOURCE: "1967 Census of Manufacturers -- Rubber and Miscellaneous Plastic Products"; U. S. Department of Commerce (issued 1970).

Table 9 - 1967 Shipments of General Latex - Based Products by U.S. Producers

readily and quickly be removed by evaporation. The second technique is coagulation-dipping where the rubber goods are produced by coagulating a film of rubber from a rubber latex onto shaped forms. Thicker-walled items are made by coagulation-dipping rather than those manufactured by the straight-dip method. The thicker rubber deposit cannot be dried as readily and must be assisted by coagulation in order that it does not disintegrate during subsequent processing.

Figure 6 is a flow diagram for a typical coagulation dipping operation. Such a facility might be engaged in the manufacture of rubber gloves. A close-loop conveyor transports the forms through various processing units. The forms can be made of glazed procelain or polished metal.

The forms are first dried and heated to 100-120° in a conditioning oven prior to dipping in the coagulant solution. The coagulant solution is usually a mixture of organic solvents and coagulants. Combinations of ethanol and acetone are generally used as solvents. Typical coagulants are calcium nitrate, calcium chloride, and zinc nitrate. A surfactant is sometimes added to the mixture to ensure good "wetting" of the forms, and release agents are added in cases where the form has a complicated shape and removal of the dipped goods from the forms is difficult. After coating with coagulants, the forms are dipped in the rubber latex. The rubber latex and ingredients are compounded prior to the dipping operation. In some cases, the latex storage and compounding tanks are cooled with cooling coils or jackets to prevent degradation of the latex. The coagulant film on the surface of the form causes the rubber emulsion to "break". The latex solids coalesce to produce a film of rubber that covers and adheres to the form.

The coated forms are passed through a preliminary drying oven to dry the film sufficiently so that it does not disintegrate and wash away in the subsequent washing step. In the washing operation the soluble constituents of the rubber film are leached out and rinsed away. Important constituents of the leachate are the emulsifiers used originally in the production of the latex and metal ions from the coagulant mixture.

The coated forms are sent through a drying oven to dry the goods. In some applications, such as rubber gloves manufacture, the goods are not only dried but heated sufficiently so that the rubber coating can be rolled downward on itself to form a reinforced cuff bead.

In most applications the rubber goods are stamped with the proprietary brands and other information such as size in a stamping unit after the drying process.

The rubber goods are cured in an oven at approximately 200°F. After curing the items are cooled in a water cooling tank and mechanically

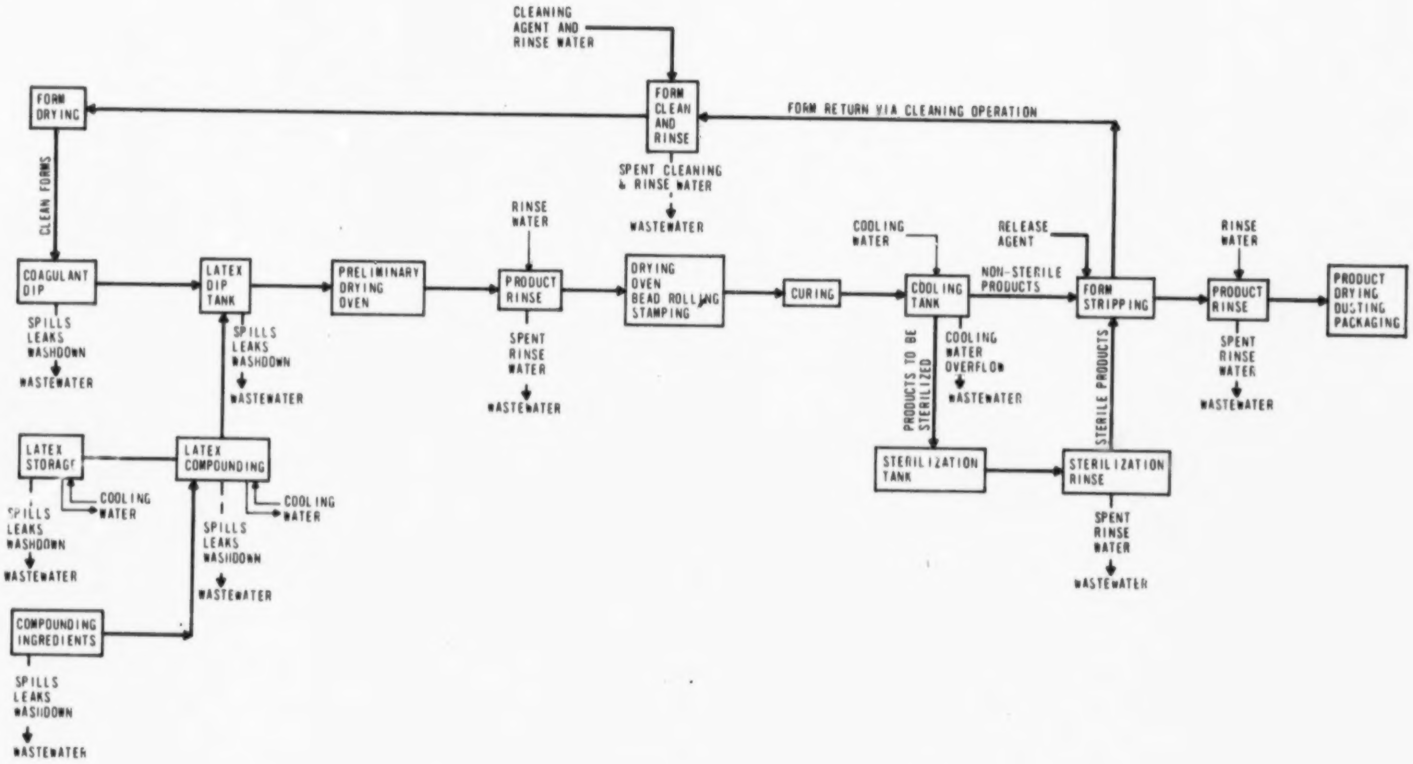

CLEANING AGENT AND RINSE WATER
FORM CLEAN AND RINSE
FORM RETURN VIA CLEANING OPERATION
FORM DRYING
CLEAN FORMS
SPENT CLEANING & RINSE WATER
WASTEWATER
COAGULANT DIP
SPILLS LEAKS WASHDOWN
WASTEWATER
LATEX DIP TANK
SPILLS LEAKS WASHDOWN
WASTEWATER
PRELIMINARY DRYING OVEN
RINSE WATER
PRODUCT RINSE
SPENT RINSE WATER
WASTEWATER
DRYING OVEN BEAD ROLLING STAMPING
CURING
COOLING WATER
COOLING TANK
COOLING WATER OVERFLOW
WASTEWATER
PRODUCTS TO BE STERILIZED
NON-STERILE PRODUCTS
RELEASE AGENT
FORM STRIPPING
STERILE PRODUCTS
RINSE WATER
PRODUCT RINSE
SPENT RINSE WATER
WASTEWATER
PRODUCT DRYING DUSTING PACKAGING
LATEX STORAGE
COOLING WATER
SPILLS LEAKS WASHDOWN
WASTEWATER
LATEX COMPOUNDING
COOLING WATER
SPILLS LEAKS WASHDOWN
WASTEWATER
COMPOUNDING INGREDIENTS
SPILLS LEAKS WASHDOWN
WASTEWATER
STERILIZATION TANK
STERILIZATION RINSE
SPENT RINSE WATER
WASTEWATER

FIGURE 6: FLOW DIAGRAM FOR THE PRODUCTION OF TYPICAL LATEX-BASED DIPPED ITEMS

stripped from the forms usually with the aid of a lubricating detergent. The detergent is subsequently washed from the goods in a rinse tank.

The final manufacturing operation consists of drying the goods, dusting them inside and outside with talc to prevent sticking and packaging.

In cases where sterilized products are required, such as surgical rubber gloves, the goods can be immersed in a chlorine dip tank (free chlorine concentration typically 1,000 mg/l) to provide disinfection and improve the surface finish of the glove. After disinfection the goods are dipped in a hot water tank (approximately 170°F) to remove the residual chlorine from the rubber product. These two operations generally occur between the post-curing cooling tank and the final drying and packaging operation. In many cases the gloves are sterilized by dipping in a hot water bath (approximately 200°F).

Periodically, it is necessary to clean the form upon which the goods are deposited. When this is necessary, the forms are passed through a bath containing a cleaning agent. In the case of porcelain forms the agent used can be chromic acid (mixture of potassium dichromate, sulfuric acid, and water). The cleaned forms are rinsed of residual chromic acid in a subsequent rinse tank. The tank is equipped with a fresh water makeup and overflow to blow down the accumulation of cleaning agent. The cleaning frequency is generally on the order of once a week. Other methods of cleaning involve simply scrubbing the forms with cleaning agents followed by rinsing.

The waste water sources and characteristics of a typical dipping operation are presented in Table 10.

The straight-dip method is the simplest of any used in making articles from latex. The forms are dipped directly into the latex and slowly removed. After dipping, the form is slowly rotated while the liquid film is drying to ensure a uniform film thickness. The films are dried at room temperature or in warm air at 120 to 140°F. Thicker articles can be made by a multiple-dipping process with drying between dips. Latex deposits vary from 0.005 to 0.10 inch per dip, depending on the viscosity of the latex compound.

Cement-Based Dipped Goods

It is appropriate to discuss the manufacture of dipped goods from rubber cement here because the production process has similarities to the manufacture of latex-based dipped goods as described above. (see Figure 7.)

Various products are made via cement dipping processes. The following process description is oriented towards the manufacture of gloves

Plant Unit or Area	Source	Nature and Origin of Waste Water Contaminants
Latex Storage and Compounding	Spills, leaks, and cleanout rinse waters	Dissolved organics, suspended and dissolved solids. High quantities of uncoagulated latex.
Coagulant Dip	Spills, leaks, and cleanout rinse water	Dissolved organics, dissolved solids.
Product Wash, Cooling, and Rinse Tanks	Spills, leaks and overflow waters	Dissolved organics, suspended and dissolved solids.
Sterilization Process	Spills, leaks, and rinse overflow waters	Dissolved solids, sterilzation agent.
Form Cleaning	Form wash and rinse waters	Dissolved organics, suspended and dissolved solids.
All Plant Areas	Area washdown and storm runoff	Organics, suspended and dissolved solids.

Table 10 - Process-Associated Waste Water Sources from Latex-Based Dipped Goods Production

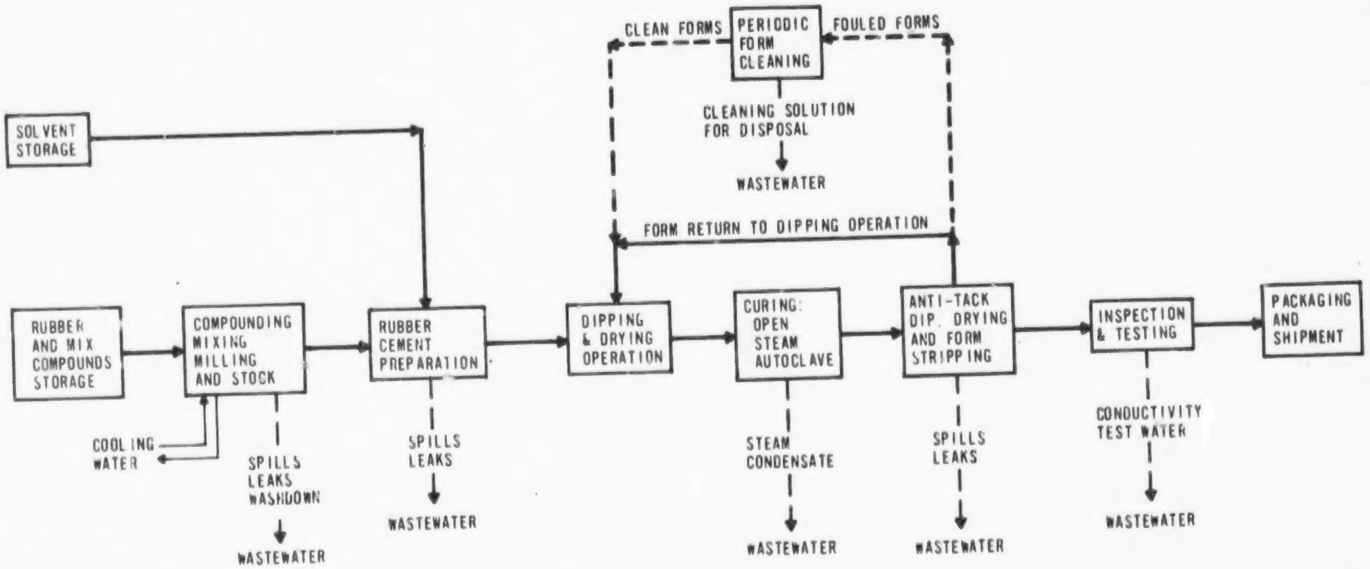

SOLVENT STORAGE
RUBBER AND MIX COMPOUNDS STORAGE
COMPOUNDING MIXING MILLING AND STOCK
COOLING WATER
SPILLS LEAKS WASHDOWN
WASTEWATER
RUBBER CEMENT PREPARATION
SPILLS LEAKS
WASTEWATER
DIPPING & DRYING OPERATION
CLEAN FORMS
PERIODIC FORM CLEANING
FOULED FORMS
CLEANING SOLUTION FOR DISPOSAL
WASTEWATER
FORM RETURN TO DIPPING OPERATION
CURING: OPEN STEAM AUTOCLAVE
STEAM CONDENSATE
WASTEWATER
ANTI-TACK DIP. DRYING AND FORM STRIPPING
SPILLS LEAKS
WASTEWATER
INSPECTION & TESTING
CONDUCTIVITY TEST WATER
WASTEWATER
PACKAGING AND SHIPMENT

FIGURE 7: FLOW DIAGRAM FOR THE PRODUCTION OF TYPICAL CEMENT DIPPED ITEMS

having a high electrical resistance. Cement dipping results in a product which has good electrical resistance since no water or ionic species are trapped in the cement as would be the case with latex dipped gloves.

The solid rubber required for the cement recipe is compounded in a small Banbury mixer or compounding mill. The recipe ingredients include antioxidants, curing agents, and pigments. The compounded stock is cut in small pieces to facilitate dissolution in the solvent. These pieces of stock are separated by weight into pre-determined quantities and placed in a bin. The wastes generated in the rubber compounding and weighing areas result from spills and leakages from machinery, powders from compounding, and washdown waste waters.

The rubber cement is prepared in blend tanks using fixed quantities of rubber stock and solvent. The solvent used is generally aliphatic in nature, for example, hexane. The blended cement is pumped to a storage tank prior to its use in the dipping operation. Several rubber cements of different colors and properties are stored simultaneously awaiting the dipping operation. Solvent and rubber cement leaks can occur in this area. The gloves are formed by dipping on glazed procelain forms. In the case of linesmen gloves the rubber layer is built up with about twenty to thirty dips. The dipped products are allowed to drip-dry between dips. The temperature and humidity of the air in the drying room is controlled to ensure good drying conditions.

When the dipping and drying operation is completed, the gloves are stamped with size and brand information and the cuff bead is formed by rolling the cuff back on itself.

The gloves are cured in an open steam autoclave vulcanizer. The temperature and length of curing depends on the type of glove and properties of the rubber. The steam condensate leaches organics from the rubber. The condensate is extremely low in volume and is discharged to the plant drain. At the end of the curing cycle the gloves are removed from the vulcanizer and left to air cool.

When partly cool the gloves are dipped in a anti-tack slurry or equivalent anti-tack agent prior to final cooling. The anti-tack slurry dries leaving a powder on the gloves which are then stripped from the forms. The gloves are dusted in a rotating drum with talc powder and sent to product inspection.

Gloves which pass a visual inspection are tested for electrical resistance. This operation involves filling the gloves with water and placing the gloves in a tank of water. A high voltage is applied between two electrodes; one electrode inside the water-filled glove and the other outside in the water-filled tank. At a given voltage, a satisfactory glove limits the current flow. Gloves removed from the tank are dried and packaged prior to shipment.

Periodically the forms require cleaning. This is carried out with a mild scouring slurry followed by rinsing of the forms. Spent scouring slurry and the rinse waters are low in volume.

The types of waste water generated by a typical cement dipping operation are listed in Table 11.

Rubber Goods from Porous Molds

Porous molds prepared from plaster of Paris or unglazed porcelain with pore sizes smaller than the smallest rubber particles, are used in the rubber sundry industry. The latex compound is poured through a funnel-shaped opening into the mold. The latex compound is allowed to dwell in the mold until a deposit of the desired thickness has developed on the mold wall. The mold is emptied of excess compound and placed in an oven to dry at 140°F for one hour. With some articles, to prevent pour lines, the mold is rotated on all planes for 15 to 30 minutes to give the latex an opportunity to flow to all extremities of the mold interior before setting. This technique is used for dolls and squeeze toys. The interior rubber surfaces are dusted with talc to prevent sticking when being removed from the mold. The article, after stripping from the plaster mold, may be returned to the 140°F oven for 30 minutes or a shorter period at a higher temperature to facilitate drying.

The types of waste water generated are similar to those produced by a latex-dipping facility. They are characterized by uncoagulated latex solids, and are evolved by spills and leaks and tank washing operations. The waste water types are similar to those produced by the manufacture of latex-dipped goods (Table 10).

Thread

The manufacture of thread from latex (referred to as "latex thread") makes use of some of the general principles and methods described above. The most widely used method is extrusion of the latex compound through fine orifices into a coagulant bath which gels the thread, followed by mechanical handling of the thread during toughening, washing, drying, and curing operations. The coagulant bath is usually dilute acetic acid.

Latex Foam

Although the number of plants and rubber companies involved in the manufacture of latex foam has decreased over the past several years, foamed-latex sponge rubber still constitutes one of the more important applications for latex, both natural and synthetic. (See Figure 8.)

Plant Unit or Area	Source	Nature and Source of Waste Water Contaminants
Oil and Solvent Storage	Spills, leaks, and storm runoff	Oil and organics pick-up by storm water.
Compounding and Weighing	Spills, leaks, and washdown	Rubber ingredient solids, oil and water leaks from mixers and mills.
Cement Preparation	Spills, leaks and washdown	Soluble and insoluble organics from solvent spills and leaks.
Curing	Condensate	Soluble and insoluble organics leached from product.
Form Stripping	Spills, leaks, and washdown	Solids from anti-tack agent.
Form Cleaning	Spills, leaks, rinse and cleaning agent discharges	Solids and surfactants from the cleaning agent.
Product Inspection	Conductivity Test Water Overflow	Water is uncontaminated.

Table 11 - Process-Associated Waste Water Sources from Cement Dipped Goods Production

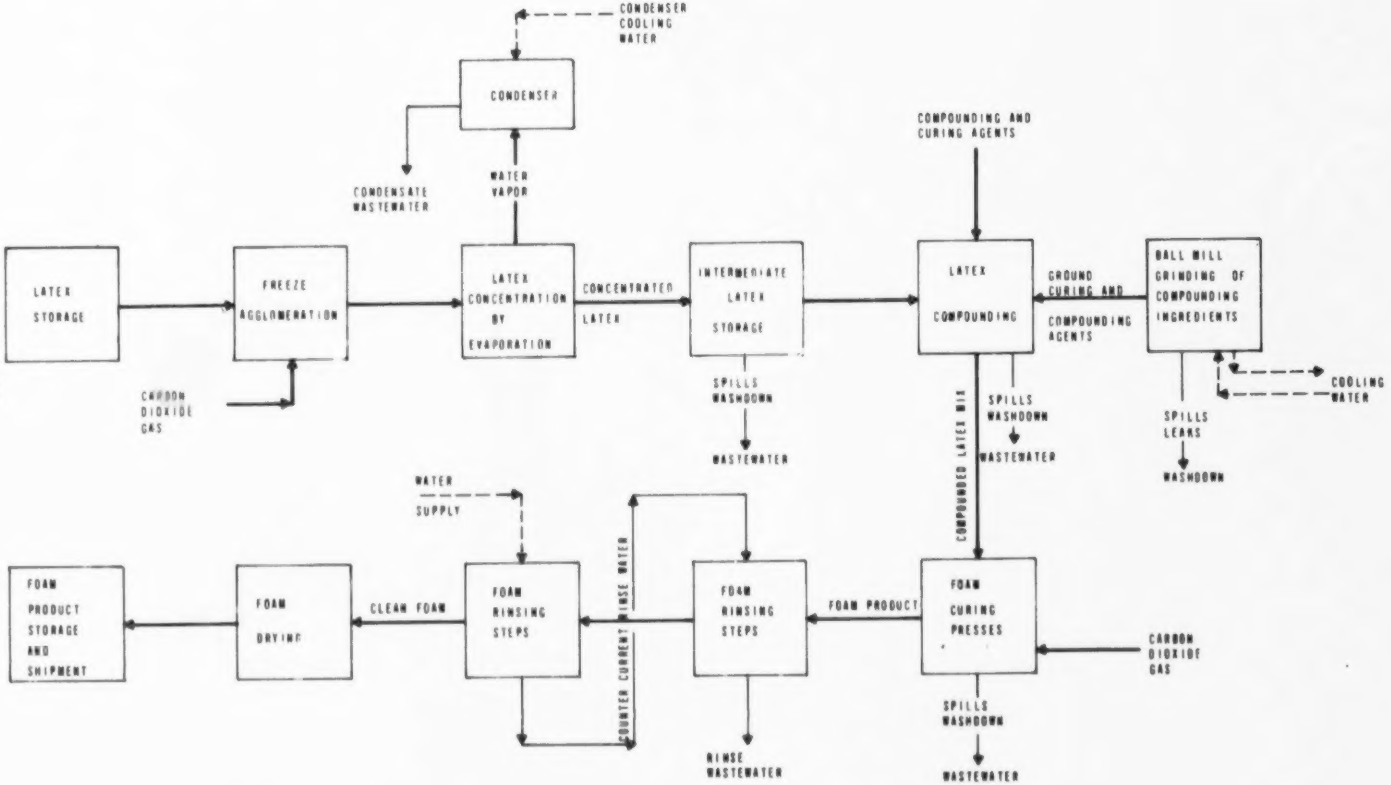

CONDENSER COOLING WATER
CONDENSER
CONDENSATE WASTEWATER
WATER VAPOR
COMPOUNDING AND CURING AGENTS
LATEX STORAGE
FREEZE AGGLOMERATION
LATEX CONCENTRATION BY EVAPORATION
CONCENTRATED LATEX
INTERMEDIATE LATEX STORAGE
LATEX COMPOUNDING
GROUND CURING AND COMPOUNDING AGENTS
BALL MILL GRINDING OF COMPOUNDING INGREDIENTS
CARBON DIOXIDE GAS
SPILLS WASHDOWN
WASTEWATER
COMPOUNDED LATEX MIX
SPILLS WASHDOWN
WASTEWATER
COOLING WATER
SPILLS LEAKS
WASHDOWN
WATER SUPPLY
COUNTER CURRENT RINSE WATER
FOAM PRODUCT STORAGE AND SHIPMENT
FOAM DRYING
CLEAN FOAM
FOAM RINSING STEPS
FOAM RINSING STEPS
FOAM PRODUCT
FOAM CURING PRESSES
CARBON DIOXIDE GAS
RINSE WASTEWATER
SPILLS WASHDOWN
WASTEWATER

FIGURE 8: FLOW DIAGRAM FOR THE PRODUCTION OF TYPICAL LATEX FOAM ITEMS

The latex may consist entirely of natural latex or synthetic SBR latex or it can be a mixture of natural and an SBR latex. The load-bearing capacity of the foams at a given density falls significantly as SBR is used in place of natural rubber. Latex rubber foams are generally prepared in slab or molded forms in the density range of 4 to 8 pounds per cubic foot.

Many different processes are patented for preparing this type of product, but there are two of prime commercial interest for manufacturing such articles as molded-foam cushioning stock. These are the Dunlop -the most widely used -- and the Talalay processes. Some producers have developed variations which in effect are a combination of the two processes.

The basic aspects of the Dunlop process are:

1. mechanically whipping the latex to a froth;
2. settling the frothed mass with a coagulant or gelling agent; and
3. vulcanizing the rubber so that the foam is permanent.

The latex is first whipped on a batch or continuous basis to produce the foam. The Oakes continuous mixer is the standard piece of equipment used by the industry to prepare the foamed latex. The gelling agents are added to this foam.

Proper coagulation of the latex to give a stable foam (commonly referred to as gelation) is the key to the process. The gelling agent is one that can be mixed into the frothed latex, then remain dormant long enough to allow the froth to be poured into molds before producing the gelling effect. The gelling system usually consists of sodium silicofluoride in conjunction with zinc oxide.

The foam is poured into molds and cured. The molds are usually steam heated. When the curing cycle is completed, the product is removed from the mold and washed with water to remove those ingredients of the latex recipe which are not held permanently in the foam matrix. The foam is dried in a hot air dryer prior to inspection, storage, and shipment.

In the Talalay process the froth is produced by chemical rather than mechanical means. Hydrogen peroxide and enzymatic catalysts are mixed into latex and the mixture is placed in the mold. Decomposition of the peroxide by the added enzyme results in the liberation of oxygen, which causes the latex mix to foam up and fill the mold. The foam is rapidly chilled and carbon dioxide is then introduced to gel the latex. The gelled foam is than handled in a manner similar to that used in the Dunlop process.

The waste water generated by the manufacture of latex foam products are similar to those produced at a latex-based dipped goods facility with the exception that there is an additional zinc-laden rinse water generated by washing the foam product. These waste waters are identified in Table 10. An important characteristic of this type of waste water is the presence of uncoagulated latex solids.

Foam Backing

For supported flat-stock foam, that is, foam backing on various fabrics such as carpets, scatter mats, upholstery fabrics, etc., a different type of gelatin agent is employed in place of the sodium silicofluoride gelling agent used in latex foam production. Either ammonium acetate or ammonium sulfate is employed in combination with zinc oxide.

The froth is prepared with an Oakes machine, the gelling agent is added at the machine, and the foam is applied to the fabric by spreading directly on the fabric or spreading on a belt and transferring the wet gel to the fabric via the belt. The gelling is carried out at elevated temperatures, usually with the aid of infrared lamps. To prevent uneven shrinkage, the fabric is carried through the high-temperature zone and drying ovens on tenter frames. For this application the foam is poured in narrow thicknesses, from 1/8 inch up to a maximum of 1/2 inch. The waste waters produced by the manufacture of foam backing are comparable to those generated by a typical latex-dipped dipped goods manufacturing facility (Table 10).

Summary

Based on the products and processes comprising the industry segment as described above, it is possible to make some general conclusions about the waste water characteristics of the industry segment and which product areas should be grouped for further discussion.

Although the types of product manufactured by molding techniques are diverse, the manufacturing processes are very similar. In addition, it is believed that the characteristics of the waste waters generated by the three principal molding technologies (compression, transfer, and injection) are comparable.

Extrusion is another fundamental rubber processing technology by which several types of products are made. Rubber extrusion, for example, is a significant step in the manufacture of rubber hose as well as belting. The waste water types throughout the industry appear to be similar and independent of the type of extruded product.

The final stage in the manufacture of many rubber products involves fabrication using molded or extruded components. In general, fabrication operations are "dry" and the necessary waste water control and treatment requirements appear to be simple.

Based on the apparent nature of the waste waters, it can be concluded that molded, extruded, and fabricated rubber products can be grouped together. The processing methods used generate waste waters limited to spills, leaks, and housekeeping operations. The waste water is characterized by oil and suspended solids loadings.

The quantity of reclaimed rubber and the number of reclaim plants have decreased dramatically over the last several years. Associated with this decline has been a conversion from the wet digestion process to both pan (heater) and dry digestion processes. Due to the differences in the waste water generated, rubber reclaiming shall be separated into two subcategories, the wet digester process, and the pan, mechanical, and dry digester process.

Two main latex-based product areas exist; latex dipped goods and latex foam. Two small latex-based product areas also exist: latex thread and items made in porous molds. The foam industry consists of one major plant. Other foam plants might exist but their capacity is insignificant. Owing to the apparent nature of the processes and the waste waters produced, latex-based products can be separated into two subcategories: latex dipped, extruded, and molded items; and latex foam.

SECTION IV

INDUSTRY CATEGORIZATION

Introduction

Industry subcategories were established to define where separate effluent limitations and standards of control and treatment should apply. The primary distinctions between the various subcategories have been based on the waste water generated, its quantity, characteristics, and applicability to control and treatment. The factors considered in ascertaining whether the developed subcategories are justified were the following:

1. Manufacturing Process
2. Product
3. Raw Materials
4. Plant Size
5. Plant Age
6. Plant Location
7. Air Pollution Control Equipment
8. Nature of Wastes Generated
9. Treatability of Waste Waters

As illustrated in Section III, there are obvious and intrinsic differences between reclaimed rubber; latex-based products; and the molded, extruded, and fabricated rubber products. Therefore, reclaimed rubber, and latex-based products, have been treated separately. Molded, extruded, and fabricated products will be treated as one group and the subcategories of the industry to which specific standards should be applied will be discussed in this section under one of the following subsections:

1. Molded, Extruded, and Fabricated Rubber Products
2. Reclaimed Rubber
3. Latex-Based Products

Molded, Extruded, and Fabricated Rubber Products

Manufacturing Process

There are two fundamental processes, molding and extrusion, by which products in this group are made. Although the manufacture of many products involves fabrication of the final product from several individual rubber components, the individual components are themselves manufactured typically by molding or extrusion techniques. The waste waters created by both molding and extrusion operations orginate with housecleaning spills, leaks, and washdown.

It can be said, therefore, that in spite of process variations, the waste waters generated by all products in this group are similar in volume and constituents and thus further subcategorization is not warranted.

Product

The basic processes of molding, extrusion, and fabrication are used to manufacture a wide array of rubber products. The waste waters associated with the majority of these products are similar and subcategorization according to product is not justified.

Hose manufacture generally produces a vulcanizer condensate exhibiting a relatively high concentration of lead (approximating 60 mg/l). The flow rate of this condensate is low (typically less than 1 gpm). Some plants utilize contact cooling water during the extrusion of the lead sheath and the cooling of the cured hose. The flow rate from these cooling operations amounts to approximately 50 gpm. However, lead-laden waste waters can be segregated and treated separately, thus separate subcategorization based on this specific waste stream is not justified.

Raw Materials

The basic raw materials for this industry group are rubber, carbon black, pigments, and oil. Although some fabrication processes use latex as an adhesive and the methods for handling latex vary the waste water problems associated with the use of latex can be overcome readily. In light of these facts, it is not reasonable to further subcategorize molded, extruded, and fabricated products based on raw material usage.

Plant Size

Study of the production facilities included in this group reveals that the size distribution is broad and ranges from approximately 500 pounds per day to 265,000 pounds per day of raw material. The small plants in this group are predominantly independent molding shops manufacturing specialized products for a limited number of wholesale outlets. At the other end of the spectrum, the larger plants tend to be integrated plants making several types of products. The medium sized and large plants are frequently operated by the large tire and rubber companies. Some products, such as hose or belting, are produced only by medium or large facilities.

Although the waste water characteristics and treatment methods of small, medium, and large plants are similar, the impact of waste water control and treatment costs on the smaller plants is likely to be more critical than their effect on large plants. This fact tends to be magnified since most small plants are operated by independent companies with less financial flexibility or resources.

Based on these observations, it was concluded that molded, extruded, and fabricated rubber products should be subcategorized in order to ascertain the cost of waste water control and treatment for three separate plant sizes. Accordingly, the molded, extruded, and fabricated rubber products has been split into three production capacity size ranges. The three size ranges, the percent of the product area covered by the size ranges, and the corresponding median, or typical, production capacity for each size range are shown below.

Range of Plant Sizes kg/day (lbs/day)	Percent of the Product Area	Typical Size For Each Range kg/day	(lbs/day)
less than 3,720 (8,200)	30	910	(2,000)
3,720-10,430 (8,200-23,000	30	7,710	(2,000)
greater than 10,430 (23,000)	40	15,420	(34,000)

Plant Age

Rubber molding, extrusion, and fabricated product plants have a broad age distribution. However, there have been few processing developments in that period that have had any significant waste water impact. In general, the waste water control and treatment costs for an older plant will probably be higher than those of a new plant, but this is not always the case. In addition, it is difficult to usefully characterize the cost-to-age relationship and to define meaningfully the age demarcation line or lines. Analysis of waste water characterization and treatment data reveal that the age of a plant does not preclude the use of exemplary control and treatment technologies.

Therefore, it has been concluded that plant age is not a significant factor for separate subcategorization.

Plant Location

Although a high proportion of the plants are located in one region of the country (Akron, Ohio and its environs), climate and geographical location are not the reasons behind this fact. Akron is the traditional center of the rubber industry where in the past raw materials (rubber and the special mix ingredients), rubber processing machinery and equipment, rubber process technology, and experienced labor have been readily available. Climate and location do not affect the basic processing techniques used by the industry and will have little impact on waste water treatability or effluent quality. Therefore subcategorization according to plant location is not necessary.

Air Pollution Control Equipment

The type of air pollution control equipment employed by the facility can have an effect on the quantity and quality of a plants overall process waste water flow. The use of dry scrubbing equipment produces no waste water problem. If wet scrubbing devices are used solid-laden blowdown can be settled and filtered. By recycling the water from the settled and filtered discharge, this waste water problem can be minimized. Plants which utilize wet scrubbers are given an additional allowance for TSS. The waste stream can be isolated and kept from interfering with the treatability of other process waste waters. Thus, air pollution control requirements do not warrant further subcategorization.

Nature of Wastes Generated

Analysis of available data indicated that the process waste water types and characteristics generated by the manufacture of general molded, extruded, and fabricated rubber products are effectively similar. Some minor variations do occur. Processes utilizing latex adhesive can produce latex-laden waste waters if inadequate water management or housekeeping practices are employed. Latex-laden rinse waters should be low in volume and can be containerized or replaceable liners can be used inside latex containers thereby eliminating the rinse waters completely. Waste waters created by wet scrubbing equipment tend to be laden with suspended solids. This waste water can be recycled with a slipstream to blowdown the accumulated solids. The slipstream is low in volume and can be containerized, treated by settling and filtration, or sent to a municipal system.

Based on these observations, it is not deemed necessary to subcategorize further according to the nature of the waste waters generated.

Treatability of Waste Waters

The control and treatment practices and technologies employed by plants are similar and are based on oil and suspended solids separation. In addition, the effluent qualities of exemplary plants of all processing types and product mixes are comparable. These facts indicate that subcategorization is not justified based on waste water treatability.

Summary

Studies of molded, extruded, and fabricated rubber products indicate that the only valid basis for subcategorization is plant size. This is not required owing to differing waste water types but because the process waste water flow rate is relatively higher for small size plant and financial resources of the smaller plants are generally weaker than those of larger rubber companies. The size-range subcategorizations, which were selected to reflect fully the potential economic and flow rate differences, are as follows:

		Model Flow l/kkg
Small Plants:	Less than 3,720 kg/day (8,200 lb/day) of raw material.	16,200
Medium Plants:	3,720-10,430 kg/day (8,200-23,000 lb/day) of raw material.	9,810
Large Plants:	Greater than 20,430 kg/day (23,000 lb/day) of raw material.	6,210

Rubber Reclaiming

Manufacturing Process

As described in Section III, there are principally three reclaiming processes used currently in the United States. Wet digestion, the oldest of the three, itself has process variations which involve rubber scrap defibering and the types of digestion medium used. In some plants, physical defibering is carried out before the digestion step; in others, chemical defibering is effected in the digestion process itself. The acidic-medium digester process is virtually extinct but alkaline- and neutral-medium process variations do exist. In addition to the wet digester process, there is the dry digester process which has fundamental process similarities to the wet process. Some wet digester systems have been or are being converted to the dry process. The pan, or heater, process is the most common reclaiming process and has almost replaced the wet digester process. The least common or least conventional process is the mechanical process and it is believed that only one plant uses this technology. Both the pan and mechanical reclaim processes need defibered scrap rubber produced by the physical defibering process.

It was concluded that there are essentially three distinct process technologies used in producing reclaimed rubber: 1) digester (wet and dry) process, 2) pan (or heater) process, and 3) mechanical process.

Product

There are primarily two types of reclaimed rubber produced by the industry. One type is general reclaim prepared from general scrap rubber items but principally scrap tires; the other type of reclaimed rubber is butyl rubber reclaim produced exclusively from scrap inner tubes. The scrap inner tube raw material requires no defibering, whereas general scrap rubber, like tires, requires either physical or chemical defibering. Although there are distinct product and process differences inherent in these two types of reclaim product, there is little waste water impact, since most reclaim plants produce the two products side by side and, in any case, the physical defibering which can be used by all reclaim plants is essentially a dry process.

It was concluded, therefore, that there were no reasonable grounds for subcategorization of the rubber reclaiming industry based on the type of product.

Raw Materials

As discussed in the section above, two basic types of raw materials, general scrap and scrap inner tubes, are used by the reclaiming industry. Since both of these can be used side by side and because the quantity of inner tube scrap is normally overshadowed by the quantity of general scrap rubber being processed in the reclaim plant, subcategorization according to raw material type is not deemed necessary.

Plant Size

Most rubber reclaiming plants in business today tend to be large production facilities. Remaining smaller plants are generally connected to municipal waste water treatment systems and, as such, are subject to pretreatment standards. It is anticipated that future reclaim plants to be constructed or re-opened will have large production capacities.

Thus, it is concluded that further subcategorization according to plant size is not warranted for rubber reclaiming facilities.

Plant Age

In general, reclaiming plants tend to be old facilities and in the past, process advances have been incorporated via modification or refurbishment rather than by the construction of grass-roots reclaiming plants using the latest process technology. Further, the age effect of process technology changes and developments are adequately taken into account by considering subcategorization based on the reclaim process used as discussed above.

Plant Location

The few surviving reclaim plants are not limited to one particular region. The location of reclaiming plants is probably linked very closely to a cheap and available supply of scrap tires. However, neither the process technology nor the waste water treatment method is dependent on the geographic location and, therefore, further subcategorization for reasons of geographic location is not required.

Air Pollution Control Equipment

Rubber reclaiming plants are infamous for the odor problems they create in the neighborhood of the plants. Wet air pollution control devices are common in the industry; however, similar control measures are required for all plants using the same reclaiming process. Therefore, subcategorization of the rubber reclaiming industry according to the extent and type of air pollution control equipment employed is not necessary.

Nature of Wastes Generated

The types and characteristics of the waste waters produced by the pan (heater), mechanical, and dry digester processes are similar although the waste waters generated by the pan and dry digester processes are probably slightly more contaminated with organics than the waste waters produced by mechanical process. Therefore, if the mechanical, dry digester, and pan processes are studied as one subcategory, the developed guidelines should be based on the exemplary treatment applicable to the pan and dry digester processes.

Such a data contraction or simplification is not detrimental to the objectives of the guidelines study since only one plant is known to use the mechanical reclaim process. The waste waters produced by the wet digester process are more contaminated than those generated by the other reclaim processes and their control and treatment are more involved. Accordingly, the rubber reclaim subcategorization is based solely on waste water types. The result is two subcategories: 1) wet digester process, and 2) other reclaim processes to include the pan, mechanical, and dry digester processes.

Treatability of Waste Waters

The treatabilities of the process waste waters produced by the pan, dry digestion, and mechanical processes are similar and are based on suspended solids and oil removal. By contrast, the waste waters created by the wet digester process, as well as requiring oil and suspended solids removal, warrant further treatment to reduce dissolved organic contaminants. In light of these differences, the reclaiming industry should be separated into two distinct subcategories: 1) wet digestion reclaimed rubber plants, and 2) pan, dry digestion, and mechanical reclaimed rubber.

Summary

In order to establish effluent limitations and standards of control and treatment, rubber reclaiming should be divided into two subcategories because of differences in the natures of the generated waste waters and their treatabilities. The two subcategories are:

1. Wet digestion reclaimed rubber
2. Pan (heater), mechanical, and dry digestion reclaimed rubber.

Latex-Based Products

Manufacturing Process

Two types of manufacturing process are predominant in the production of latex-based products. Dipped goods, such as surgical gloves, are made by single or multiple dipping operations. Latex foam production, on the other hand, involves the frothing or foaming of rubber latex followed by curing. It should be noted that although the two process technologies exhibit distinct differences there are strong similarities in the two processes from the standpoints of materials handling and waste water characteristics. It was apparent that latex-based products should be tentatively subcategorized into dipped goods and foam in order to reflect the differences in the process technologies. Latex-based products such as latex thread and items formed in porous molds, although minor product types, must be considered separately until final conclusions can be made as to which subcategory they should be assigned.

Product

The products made from latex-based raw materials are varied. However, the manufacturing processes, waste water characteristics, and treatment efficiencies of many of these product types are similar. Therefore, only four product segments are required. These segments are dipped goods and latex foam as well as the minor products, latex thread and porous mold items.

Raw Materials

The basis for the separation of latex-based products from the rest of the segment covered by these guidelines and limitations was the fact that rubber latex was the common raw material. The various types of rubber latex used do not have differing waste water impact and thus there is no need for further subcategorization according to the type of raw material used.

Plant Size

The size distribution of dipped goods manufacturing facilities is relatively confined, and it is not necessary to study the waste water characteristics and treatment techniques of several plant sizes for this subcategory. The one known latex foam plant has a raw material usage of 200,000 lbs/day latex solids and is large in comparison with latex dipping facilities. It is believed by many rubber industry experts that no other foam production facilities exist in the United States. It is certainly true to say that few significant latex foam plants are currently operating. Therefore, only one size of foam plant will be studied, namely that of the plant that is known to exist.

Plant Age

The process technology used by the latex dipping industry has not changed significantly since the advent of the industry, and therefore plant age is not considered a necessary factor for further subcategorization. Since there is only one significant latex foam production facility, plant age is not a reason for subcategorization of the latex foam category. This approach is supported by the fact that the changes in latex foam production methods over the years have not had a waste water impact.

Plant Location

Geographical location does not have any effect on the process technologies or waste water treatments used in either the latex dipping or foam producing industries. Thus plant location is not justified as a factor for subcategorization. Climatic conditions, such as temperature, will affect the rate of biodegradation. However, climatic effects can be taken into consideration during the design of a treatment facility such that the effluent limitations can be complied with throughout the U.S.

Air Pollution Control Equipment

Few air pollution controls and no wet scrubbing devices are used by plants manufacturing either latex dipped goods or foam. Accordingly, air pollution control equipment needs do not constitute grounds for further subcategorization of the industry.

Nature of Wastes Generated

Waste waters generated are characterized by latex solids, which result from spills or leaks around loading/unloading areas, and from operations associated with tankage, blending, and product wash facilities. Product and equipment washing operations result in surfactants entering the waste water. A separate problem for the latex foam industry is the existence of high zinc concentrations in the foam rinse operations.

Based on the specific characteristics of the zinc-laden foam rinse waters, the latex-based products industry is divided into two subcategories: dipped goods (including thread and porous mold items) and latex foam.

Treatability of Waste Waters

The treatability of latex-laden waste waters from all types of production facilities can be treated similarly with chemical coagulation and clarification for primary treatment and biological treatment for the removal of soluble contaminants. The zinc-laden waste waters generated in foam plants require chemical precipitation and clarification as primary treatment followed by biological secondary treatment.

With this in mind, it was deemed necessary to separate latex products into two separate subcategories, dipped goods (as well as thread and porous mold items) and latex foam, based on the different treatabilities of the waste waters.

Summary

Analysis of latex-based products manufacturing, point to subcategorization based on process, plant size, waste water characteristics, and treatability. Therefore, the subcategorization should be:

1. Dipped goods, latex thread, and items made in porous molds.
2. Latex foam.

Summary

The considerations presented in this section substantiate the following subcategorization:

Small-sized general molded, extruded, and fabricated rubber plants subcategory; medium-sized general molded, extruded, and fabricated rubber plants subcategory; large-sized general molded, extruded, and fabricated rubber plants subcategory; wet digestion reclaimed rubber subcategory; pan, dry digestion, and mechanical reclaimed rubber subcategory; latex-dipped, latex-extruded, and latex-molded subcategory; latex foam subcategory.

SECTION V

WASTE CHARACTERIZATION

General Molded, Extruded, and Fabricated Rubber Subcategories

General

Waste water characterization data was obtained from literature, EPA documents, and company data. Plant visits (refer to Section VII) were made to confirm this data. Figures 1, 2, 3, 4 and 7 are generalized process diagrams of typical molded, extruded, hose, footwear, and cement-dipped production facilities, respectively; they indicate the location of water supply and waste water generation streams.

Total Effluent

Table 12 summarizes total effluent quantities and contaminant loadings. All data is normalized to a unit of raw material consumption. Indicated flow rate values include both process and nonprocess waste waters. Nonprocess waste water can include once-through cooling water, cooling tower blowdown, boiler blowdown, intake water treatment wastes, domestic wastes, and steam condensate. The largest portion of the total effluent flow is cooling water discharge. Fluctuations in the flow rates generally reflect water management practices. For instance, plants G and C use recirculated cooling water, whereas plants A and D have once-through cooling systems.

Values tabulated for raw waste loads include both process and nonprocess waste waters. In addition to the values listed, tests were conducted for other contaminants, such as phenols, chromium, and zinc. Phenol content in all the plants visited was minimal and it can be assumed that phenols in Subcategories E, F, and G total raw effluents will not be significant. Chromium and zinc can be present in the total plant effluent from nonprocess waste waters evolved from cooling tower blowdowns, but concentrations are usually below the measurable level. As with flow rates, COD and BOD loadings reflect water management techniques. Typically, the use of cooling water treatment chemicals in recirculated cooling water systems will raise the COD and BOD loadings in the final effluent.

Suspended solids and oil loadings are attributable to process waste water discharges. These loadings in the total effluent appear minor when compared to COD and BOD loadings. There are two major reasons for this: first, process flow rates are minor relative to nonprocess discharges and dilution by nonprocess waste waters reduces their concentrations in final raw effluents; secondly, the plants listed have exemplary features. Sound housekeeping and maintenance practices (i.e., care to prevent spills, dry pickup of spills, and repair of

Plant	Product Type	Size[1]	Flow L/kkg (gal/1000 lb) of raw material	COD kg/kkg (lb/1000 lb) of raw material	BOD kg/kkg (lb/1000 lb) of raw material	SS kg/kkg (lb/1000 lb) of raw material	TDS kg/kkg (lb/1000 lb) of raw material	Oil kg/kkg (lb/1000 lb) of raw material	Lead kg/kkg (lb/1000 lb) of raw material
A	Seals, General Molded Items, Rubber-Metal Bonded Items	1	69,771 (8,362)	1.395	1.646	0.0676	46.899	1.785	-
B	Cement Dipped Gloves	1	11,340 (1,359)	0.028	0.037	0.102	4.354	0.010	-
C	Molded Sport Grips, Rubber-Metal Bonded Items	2	10,560 (1,265)	0.528	0.249	0.137	8.342	0.074	-
D	Hose, Various Sizes	2	120,042 (14,405)	2.404	1.214	0.120	72.841	0.094	0.001
E	Belting and Sheet Rubber	3	22,122 (2,651)	1.349	0.194	0.221	68.598	0.103	-
F	Large Seals and Weather Stripping	3	29,683 (3,557)	1.703	0.161	1.828	25.109	0.138	-
G	Hose, Various Sizes	3	7,290 (875)	1.903	0.205	0.28	2.753	0.224	0.059
H	Canvas and Cement Dipped Footwear	3	60,369 (7,235)	4.601	0.385	1.734	12.886	0.394	-

[1] Size 1 less than 3,720 kg/day (8,200 lb/day) raw materials consumption.
Size 2 3,720 - 10,430 kg/day (8,200 - 23,000 lb/day) raw materials consumption.
Size 3 greater than 10,430 kg/day (23,000 lb/day) raw materials consumption.

[2] Included utility waste waters.

Table 12: Raw Waste Loads of Total Effluent from Subcategories E, F, and G Plants with Exemplary Features

leaking machinery and pipes) substantially reduce suspended solids and oil loadings in raw effluents.

Dissolved solids loadings in the raw effluents is a function of both the water management techniques, particularly with utility services, and the quality of the water supply source. Typically, the use of a cooling water recirculation system or the use of an underground raw water source will increase the dissolved solids loadings in the final effluent.

The raw waste waters from Plant D and Plant G contain lead and, in general, have a higher COD content. This is attributable to vulcanization techniques employed in hose manufacturing.

Raw waste water loadings of Plant B are lower than those of the other plants. This plant produces cement dipped goods. Their manufacture requires less heavy machinery and a correspondingly smaller amount of nonprocess and process waste waters are evolved.

Individual Process Streams

The primary source of process waste waters within the general molded, extruded, and fabricated rubber subcategories is related to the use of heavy machinery, and various anti-tack solutions. Leakage of bearing, gear, and seal oil can readily pass into nearby drains and be carried into the waste water effluents. Oil powered hydraulic systems provide additional potential for oil contamination of waste waters. Anti-tack agents which are allowed to spill onto the floor can, when not properly handled, contaminate plant effluents, contributing a potentially high suspended solid loading. Washdown of the dipping areas where anti-tack agents are in use will create an additional suspended solids loading in the effluents. In addition, uncontrolled or untreated runoff from outdoor oil storage areas will contribute to additional oil loadings in the effluent. Flow, oil, and suspended solids contributions from these sources are the major components of the total process effluent. Smaller plants, with a typically less efficient operation (smaller throughput per machine) and older machinery, normally have higher oil and suspended solids loadings per pound of raw material usage. Larger storage areas in relation to production level are also typical of smaller plants and potential contamination from these areas is relatively greater.

The discharge from wet air emission control devices is another process waste water which, although of less significance, is common to the general molded, extruded, and fabricated rubber subcategories. Particulate air collection equipment is necessary in the compounding areas and those areas where grinding or buffing of rubber occurs. This would include such processes as buffing of products to remove flash and the grinding of rubber from metal parts. Air pollution control devices in the compounding areas are typically the dry bag-type collectors. Devices in other areas can be either wet or dry.

Other process waste waters of minor importance include the discharge of contact cooling water, product testing waters, and spillage of mold release solution. Product testing and contact cooling waters are not contaminated and in some cases are recycled. Mold release solutions are usually applied manually. Spillage from this area is minute and easily controlled.

Process waste waters specific to particular products within this industry include vulcanizer condensate from the curing of both lead-sheathed and cloth-wrapped hoses, vulcanizer condensate from the curing of cement dipped items, and latex discharges from fabricated rubber production facilities.

Discharges of condensate from the curing of lead sheathed hose are characterized by a high lead concentration (approximately 60 mg/l). However, a relatively small lead loading results, due to the extremely low flow rates of the condensate. Cooling water used on the lead press and cured hose do contribute significant amounts of lead-laden waters, approximately 22,400 gpd for a 28,750 lb/day plant.

Vulcanizer condensate from the curing of cement dipped goods is characterized by high COD concentrations (approximately 800 mg/l) resulting from solvents removed from the product during curing operations. Flow rates, however, are small, resulting in minor COD loading (0.4 kg/kkg of raw material). The vulcanizer condensate produced during the curing of cloth-wrapped hose has a lower COD concentration and loading than the cement-dipped condensate.

Latex discharges are characterized by COD, BOD, and suspended solids loadings, but with proper handling and controls they are relatively minor.

In summary, the major process streams are:

1. Spills, leakage, and washdown, from processing areas, and runoff from outdoor storage areas.
2. Vulcanizer condensate from the curing of lead-sheathed and cloth-wrapped hoses, cooling water from the lead sheathing press (or extruder), and waters from the cooling of cured lead-sheathed hose.
3. Vulcanizer condensate from the curing of cement dipped items. Flow rates and loadings for these streams are listed in Table 13.

Waste Water Types	Size[1]	Product Types	Flow L/kkg(gal/1000 lb) of raw materials	COD Kg/kkg(lb/1000 lb) of raw materials	COD mg/L	SS Kg/kkg(lb/1000 lb) of raw materials	SS mg/L	Oil Kg/kkg(lb/1000 lb) of raw materials	Oil mg/L	Lead Kg/kkg(lb/1000 lb) of raw materials	Lead mg/L
General Process Wastes											
Spills, Leaks, Washdown and Runoff	1	All Product Types	16,200 (1,944)	2.960	182	3.500	216	1.000	62	-	-
Spills, Leaks, Washdown and Runoff	2	All Product Types	9,810 (1,177)	1.770	180	1.220	122	0.600	60	-	-
Spills, Leaks, Washdown and Runoff	3	All Product Types	6,210 (745)	1.120	180	0.900	145	0.380	61	-	-
								-	-	0.030 0.030	63 63
Specific Process Wastes											
Vulcanizer Condensate	All Sizes	Hose manufactured by the lead sheathed cure process	450 (54)	-	-	0.030	63	-	-	-	-
Vulcanizer Condensate	All Sizes	Cement Dipped Goods and Hose manufactured by the cloth wrapped cure process	528 (63)	0.435	823	0.005	10				

[1] Size 1: less than 3,720 kg/day (8,200 lb/day) raw materials consumption.
Size 2: 3,720 - 10,430 kg/dav (8,200 - 23,000 lb/day) raw materials consumption.
Size 3: greater than 10,430 kg/day (23,000 lb/day) raw materials consumption.

[2] Data obtained from U.S. Army, Corps of Engineers - Discharge Permit and Plant Visit Sources.

Table 13: Raw Waste Loads of Process Effluent from Typical Subcategories E, F, and G Facilities[2]

Summary

Based on the discussion above, several conclusions can be drawn about the waste waters generated by Subcategories E, F, and G:

1. Process waste waters are of a low flow rate and have little impact on the total effluent flow rate.

2. The most significant process waste water streams occur by spillage, leakage, washdowns, and runoff. They contribute the majority of the suspended solids and oil in the final effluent. The flow rate of this type of process waste water is dependent on plant size, and increases relative to production level as plant size decreases.

3. Other process streams worthy of consideration are vulcanizer condensate and contact cooling water from the lead-sheathed and cloth-wrapped hose production and cement dipped goods manufacture.

4. Other process streams are of negligible importance, their impact being minor or undetectable.

Subcategory H -- Wet Digestion, and Subcategory I -- Pan (Heater), Mechanical, and Dry Digestion Reclaimed Rubber Industries

General

Data for characterizing the two reclaim subcategories were obtained primarily from EPA documents and the companies. A data collection visit was made at a plant which used both the wet digester and pan processes in order to obtain further first-hand information. Since the total number of facilities producing reclaimed rubber is small, each existing plant was also interviewed to supplement the primary data on processing techniques, and waste water types and treatment methods.

Total Effluent

Table 14 summarizes the total process and nonprocess waste water effluent quantities and contaminant loadings of the plant visited. All data are normalized to a unit of weight of reclaimed rubber product. Table 15 presents raw waste loads of process waste water effluents.

The flow rates presented include both process and nonprocess waste waters. For this plant, nonprocess waste waters include once-through cooling water and steam condensate. Nonprocess water contributes the bulk of the flow rate.

Rubber scrap coming to the plant is segregated. Tires are reclaimed by the wet digester process; whereas fiber-free scrap, such as inner

Plant	Product Type	SUBCATEGORY	Flow L/kkg (gal/1000 lb) of products	COD kg/kkg (lb/1000 lb) of products	BOD kg/kkg (lb/1000 lb) of products	SS kg/kkg (lb/1000 lb) of products	TDS kg/kkg (lb/1000 lb) of products	Oil kg/kkg (lb/1000 lb) of products
I	Reclaimed Rubber	H	89,451 (10,720)	4.686[2]	0.896	1.890[1]	11.832	0.427[2]
I	Reclaimed Rubber	I	74,765 (8,960)	2.813	0.535	1.246	7.801	0.210

[1] Value does not include any fiberous material which is removed at this plant prior to digestion.

[2] Includes reductions made through the reuse of digester liquors.

[3] Includes utility waste waters.

Table 14: Raw Waste Loads of Total Effluent from Subcategories H and I Plants with Exemplary Features

	Flow	COD		BOD		SS		Oil	
	L/kkg(gal/1000 lb) of products	kg/kkg(lb/1000 lb) of products	mg/L	kg/kkg(lb/1000 lb) of products	mg/L	kg/kkg(lb/1000 lb) of products	mg/L	kg/kkg(lb 1000/lb) of products	mg/L
SUBCATEGORY H: Wet Digester Process									
Spills, Leaks, Washdown and Runoff	3130 (374)	0.345	110	0.085	27	0.190	287	0.760	240
Vapor Condensate from Air Pollution Control Devices	1620 (195)	0.396	240	0.108	70	0.108	70	0.783	480
Dewatering Liquor (Chemical Defibering)[1]	2391 (286)	9.010	3910	1.800	790	256.000	106,650	25.747	10,770
Dewatering Liquor (Mechanical Defibering)	2391 (286)	9.010	3910	1.800	790	1.400	585	25.747	10,770
SUBCATEGORY I: Pan, Dry Digester and Mechanical Process									
Spills, Leaks, Washdown and Runoff	3130 (374)	0.345	110	0.085	27	0.190	287	0.483	154
Vapor Condensate from Air Pollution Control Devices	160 (20)	0.055	343	0.025	160	0.001	8	0.010	65

[1] The characteristics of dewatering liquor generated in a chemical defibering process are estimates based on the quantity of fiber in scrap tires. The suspended solids values represent maximum levels. It is possible that much of the suspended solids will be converted to dissolved solids during the chemical defibering process.

Table 15: Raw Waste Loads of Process Effluents from Typical Subcategories H and I Processes

tubes, is fed to the pan process. Since tire reclaiming requires additional grinding and associated cooling water, particularly as preparation for the mechanical defibering operation, the wet digester process waste water flow rates are higher than those of the pan process. Incidentally, if tires were reclaimed by the pan process, the flow of nonprocess cooling water would be greater.

The nonprocess cooling water is relatively contaminant free, containing COD, BOD, and suspended solids attributable to the water source rather than the reclaiming process. Therefore, the contaminant loadings presented in Table 14 are almost entirely attributable to process waste water streams.

In the wet digester process (Subcategory H), the major constituents include COD, BOD, suspended solids, and oil. Analytical testing was made for phenols and heavy metals, in particular zinc, but the levels were negligible. The existing wet digester processes do not produce zinc-laden waste waters as were encountered with the older or more conventional digester processes.

Values presented in Table 14 for Subcategory H represent raw waste loads after in-plant control. As mentioned earlier, fiber is removed from the scrap mechanically, thereby reducing the suspended solids loading of the effluent. In addition, dewatering liquors and vapor condensates are reused as makeup to the digester, thus reducing final oil and COD loadings. The final loadings of importance are oil, suspended solids, and COD.

In the reclaim processes for Subcategory I (including pan, mechanical and dry digestion reclaim processes) the process waste waters have lower flow and contaminant loadings than the wet digestion process. This is due to the absence of the dewatering liquor waste water stream and the lower usage of depolymerizing oils in the dry reclaiming processes.

Individual Process Streams

The primary source of process waste water loadings for Subcategory H is dewatering liquor. High COD and oil loadings are characteristic of this discharge. When mechanically defibered scrap is fed to the wet digester process, suspended solids are contained in the dewatering liquor owing to carrying over of depolymerized rubber fines. If defibering is carried out chemically in the digestion step, additional suspended solids due to the fiber will be present.

A second major source of contaminant loadings for both Subcategory H and Subcategory I is spills, leaks, and washdown from processing areas. The discharge is qualitatively similar to the corresponding discharge of Subcategories E, F, and G; however, flow rates and loading on a per-day basis are substantially higher.

A third major source of contaminant loadings is air control equipment used to collect light organics which are vaporized or entrained in the vapors leaving the pan devulcanizers or the wet digester system. Flows and loadings from the wet digester process are substantially higher than those of the pan process. In the wet digestion process, the oil contained in these condensates can be recycled.

Summary

Waste waters generated by rubber reclaiming, Subcategories H and I, contain the following major contaminant constituents: COD, suspended solids, and oil. Analysis of waste waters from rubber reclaiming plants, indicates that zinc and phenol are not present in significantly measurable quantities. For subcategory H, dewatering liquor contributes the majority of the total COD, oil, and suspended solid loadings. In both subcategories, spills, leaks, washdown, and runoff from processing areas are a substantial source of effluent contamination. Additional contamination is attributable to the control of vapor emissions from both the pan and wet digester processes.

Loadings for waste waters from Subcategory H are substantially higher than those of Subcategory I. In-plant controls such as the use of mechanically defibered scrap and the recycle of dewatering liquors does not reduce the waste water loadings associated with the Subcategory H process to the levels resulting from the Subcategory I reclaiming process.

Latex-Based Products Subcategories

General

Waste water characterization data for Subcategories J and K were obtained from literature, EPA documents, company records, and first-hand plant data. Plant visits (refer to Section VII) were made at two latex dipping facilities and one latex foam plant. Generalized process flow diagrams, indicating both product flow and waste water generation points, are presented in Figures 6 and 8.

Total Process Effluent

Table 16 summarizes the total process effluent quantities and contaminant loadings discharged by plants manufacturing latex-based products. All data is normalized to a unit of latex consumption. Flow rates are higher for the latex foam due to the larger amounts of processing and product washing waters required.

Effluent streams were measured for COD, BOD, suspended solids, dissolved solids, oil, surfactants, zinc, and phenols. Phenols were not found in any of the waste waters. Zinc was found in process waste

Plant	Product Type	Flow L/kkg(gal/1000 lb) of raw material	COD kg/kkg(lb/1000 lb) of raw material	BOD kg/kkg(lb/1000 lb) of raw material	SS kg/kkg(lb/1000 lb) of raw material	TDS kg/kkg(lb/1000 lb) of raw material	Oil kg/kkg(lb/1000 lb) of raw material	Surfactants kg/kkg(lb/1000 lb) of raw material	Zinc kg/kkg(lb/1000 lb) of raw mat rial
J	Latex Dipped Prophylactics, Balloons, Finger Cots	43,200 (5,180)	7.60	5.75	3.38	49.50	0.24	0.08	-
K	Latex Dipped Gloves	102,920 (12,350)	69.73	15.66	310.70	39.58	13.30	0.66	-
L	Latex Foam Rubber	17,700 (2,124)	75.85	20.44	8.71	23.94	10.11	0.09	3.54

[1] Utility waste waters not included.

Table 16: Raw Waste Loads of Process Effluents from J and K Facilities with Exemplary Features

waters from the latex foam facility. No zinc was found in waste waters generated by latex dipped facilities. COD, BOD, suspended solids, and dissolved solids are attributable to latex in the waste water. Loadings for Plant K are substantially higher because of the contributions of detergent-laden wash waters which also produce a higher flow. Surfactants are contributed by the emulsifying agents used in the latex mix and additionally in Plant K by the detergent present in the washing waste waters.

Individual Process Streams

The principal source of waste waters within these subcategories is product wash waters. These wash waters are characterized by a COD, BOD, dissolved solids, and suspended solids loading. The loadings of these waste waters are highly dependent on the washing techniques employed by the company. Company K uses detergents in the washing operations, whereas Company J uses only high temperature water (approximately 200°F). The use of detergents adds to COD and BOD loadings in the raw effluent. Flows are also highly dependent on the technique employed. Higher flow rates are normally envolved from multiple washings.

In addition to the other loadings, discharges of product wash water from latex foam facilities can contain high concentrations of zinc. Zinc oxide is used as a curing agent during foam manufacture. Zinc components, which are not held, or fixed, in the foam matrix are removed by the wash waters.

A second source of contamination results from spills, leaks, washdown, and runoff from latex storage, compounding, and transfer areas. This waste water will contain latex and is characterized by COD, BOD, suspended solids, dissolved solids, oil, and surfactant loadings. COD, BOD, and suspended solids are present due to the latex in the waste water. Oil and surfactants are contributed by coagulation agents, extractable organics, and emulsifier aids.

A third source of waste water, relevant to latex dipping operations, is form cleaning wastes. Plant J employed a biodegradable cleaning compound in hot water. The operation is continuous, the form being cleaned automatically after each complete dipping operation. Waste waters from this operation are characterized by loadings of COD, BOD and suspended solids. Plant K cleans forms manually and only periodically. Discharges from this area, although characterized by similar contaminants, will be intermittent in nature and will be of a substantially lower flow. Literature and EPA documents indicate that certain latex dip operations use chromic acid solutions to clean forms. If not containerized, these waste waters will appear in the process effluent.

A summary of the individual process stream characteristics is presented in Table 17.

Summary

Process waste waters from Subcategories J and K operations are characterized by COD, BOD, suspended solids, oil and surfactant loadings. In addition, discharges from these operations can contain significant quantities of zinc and chromium. The primary waste water is product wash waters. The characteristics of the wash water is highly dependent on the techniques employed. In the production of latex foam, the wash water will contain zinc. Other sources of process waste waters include spills, leaks, washdown, and runoff from latex storage, compounding and transfer areas, and discharges from form cleaning operations.

Waste Water Type	Flow	COD		BOD		SS		Surfactants		Zinc	
	L/kkg (gal/1000 lb) of raw material	kg/kkg (lb/1000 lb) of raw material	mg/L	kg/kkg (lb/1000 lb) of raw material	mg/L	kg/kkg (lb/1000 lb) of raw material	mg/L	mg/kkg (lb/1000 lb) of raw material	mg/L	kg/kkg (lb/1000 lb) of raw material	mg/L
SUBCATEGORY J											
Spills, Leaks, Washdown[1] and Runoff from Latex Storage, Compounding and Dip Tank Areas	476 (57)	-	-	-	-	1.86	3,900	-	-	-	-
Single Product Wash and Rinse Waters[2]	43,200 (5,180)	7.60	176	5.75	133	3.38	78	0.08	2	-	-
Multiple Product Wash and Rinse Waters[2]	381,000 (45,710)	41.14	108	9.24	24	3.51	9	0.66	2	-	-
SUBCATEGORY K											
Foam Rinse Waters	3,600 (432)	47.63	13,230	17.62	4,900	25.22	7,000	0.09	25	3.51	975
Spills, Leaks, Washdown and Runoff from Latex Storage, Compounding and Transfer Areas	600 (72)	17.51	29,180	2.17	3,620	0.72	1,200	0.002	3	0.02	33

[1] Obtained from available U.S. Army, Corps of Engineers - Discharge Permit Information; not necessarily typical.

[2] Both single and multiple product wash and rinse water streams do not exist at any one plant.

Table 17: Raw Waste Loads of Process Effluents from Typical Subcategories J and K Facilities

SECTION VI

SELECTION OF POLLUTION PARAMETERS

Subcategories E, F, G -- General Molded, Extruded, and Fabricated Rubber Products

From review of the Corps of Engineers Permit Applications for molded, extruded, and fabricated rubber production facilities and from examination of related published data, it appears that the following pollutants are present in measurable quantities in the waste water effluents from Subcategories E, F, and G production facilities:

BOD
COD
Suspended Solids
Total Dissolved Solids
Oil and Grease
pH
Temperature (Heat)
Lead
Chromium

Examination of in-plant and analytical data obtained during the on-site inspections of a number of production facilities indicates that certain parameters: are present only in insignificant amounts; are present in the raw supply water; or are contributed by discharges unrelated to the primary production operations. Nonprocess effluents result mainly from utility and water treatment discharges and from domestic waste water discharges generated within the plant boundaries. Such nonprocess discharges are the subject of other guideline studies and are covered by other EPA documents.

The topics treated in this section include the rationale for elimination or selection of the aforementioned parameters and recommendations.

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) refers to the amount of oxygen required to stabilize biodegradable organic matter under aerobic conditions. BOD concentrations measured in process waste waters discharged by Subcategories E, F, and G production facilities were typically low, i.e., less than 30 mg/l. Their presence is due in general to the organic content of oil and grease, and anti-tack and latex solutions. The presence of these solutions in waste waters is better characterized however by the oil and grease, and suspended solids loadings. Consequently, BOD was considered insignificant in the effluent of plants manufacturing general molded, extruded, and fabricated rubber products.

Biochemical oxygen demand (BOD) is a measure of the oxygen consuming capabilities of organic matter. The BOD does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes of decomposition exert a BOD, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all inhabitants of the affected area.

If a high BOD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations.

COD

Chemical oxygen demand (COD) provides a measure of the equivalent oxygen required to chemically oxidize the organic/inorganic material present in the waste water sample. COD in Subcategories E, F, and G process waste waters is attributable to washdown and runoff from contaminated oil, to anti-tack dipping, and the latex areas. Intermittent discharges of spent anti-tack or latex solution contribute to the COD of process waste water. Discharges of vulcanizer condensate in cement-dipped goods production and certain hose production also increase COD loadings. Flow rates from these COD-contributing waste waters is small, thus resulting in low COD loadings. Technology is not available for adequate and viable treatment of such small COD loadings. In addition, other parameters (such as suspended solids and oil) more readily characterize the COD loading. Accordingly, it is not deemed necessary to subject Subcategories E, F, and G production process effluents to COD limitations.

Total Suspended Solids

Suspended Solids (SS) after discharge to a water course can settle to the bottom, blanket spawning grounds, interfere with fish propagation, and may exert an appreciable oxygen demand on the body of water. Suspended solids in Subcategories E, F, and G waste waters are due to washdown and runoff from compounding areas, discharges of anti-tack solution and boiler blowdowns, and water treatment wastes. During normal daily production operations, the nonprocess blowdowns and the water treatment wastes will contribute the largest amounts of suspended solids. Suspended solids concentrations in process waste waters will vary from less than 10 mg/l (with proper in-plant controls) to over 20,000 mg/l during anti-tack solution dumping and discharge.

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography; cooling systems, and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.

Total Dissolved Solids

High concentrations of dissolved solids (TDS) originate from the nonprocess waste water effluents from cooling towers, boiler blowdowns, and water treatment system backwashes and blowdowns. In addition, high concentrations of TDS were observed in all effluents when the raw water supply was from deep wells as opposed to city water.

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated whereas they could not be in temperate climates. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with cleanness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Oil and Grease

Oil and grease is a measure of the insoluble hydrocarbons and the free-floating and emulsified oil in a waste water sample. Oil and grease exist in process waste waters due to washdown, runoff, spills, and leakage in the process areas which pick up lubricating oil from machinery, and process and fuel oil from storage areas. Concentration values in the total effluent range from less than 5 mg/l to greater than 100 mg/l. Concentrations in the total plant effluent are not directly indicative of the oil and grease problem because of dilution by nonprocess waste waters. Loadings in the plants visited ranged from 0.1 kg/kkg to 1.8 kg/kkg of raw material. Since oily wastes result from intermittent flows, instantaneous values could be much higher at times.

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to inhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and coats of water animals and fowl. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

pH, Acidity and Alkalinity

Control and adjustment of pH in the process waste waters generated in the Subcategories E, F, and G should be practiced. Failure to maintain adequate control can have a deleterious effect on aquatic life, post-precipitation of soluble salts, etc.

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

Temperature

Elevated temperatures in total plant effluents occur when collected steam condensate (utility waste) is not recycled but is discharged into the plant effluent. Elevated temperatures are not encountered in process waste waters. Consequently, a temperature limitation for process waste waters is not considered necessary.

Temperature is one of the most important and influential water quality characteristics. Temperature determines those species that may be present; it activates the hatching of young, regulates their activity, and stimulates or suppresses their growth and development; it attracts, and may kill when the water becomes too hot or becomes chilled too suddenly. Colder water generally suppresses development. Warmer water generally accelerates activity and may be a primary cause of aquatic plant nuisances when other environmental factors are suitable.

Temperature is a prime regulator of natural processes within the water environment. It governs physiological functions in organisms and, acting directly or indirectly in combination with other water quality constituents, it affects aquatic life with each change. These effects include chemical reaction rates, enzymatic functions, molecular movements, and molecular exchanges between membranes within and between the physiological systems and the organs of an animal.

Chemical reaction rates vary with temperature and generally increase as the temperature is increased. The solubility of gases in water varies with temperature. Dissolved oxygen is decreased by the decay or decomposition of dissolved organic substances and the decay rate increases as the temperature of the water increases reaching a maximum at about 30°C (86°F). The temperature of stream water, even during summer, is below the optimum for pollution-associated bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant.

Reproduction cycles may be changed significantly by increased temperature because this function takes place under restricted temperature ranges. Spawning may not occur at all because temperatures are too high. Thus, a fish population may exist in a heated area only by continued immigration. Disregarding the decreased reproductive potential, water temperatures need not reach lethal levels to decimate a species. Temperatures that favor competitors, predators, parasites, and disease can destroy a species at levels far below those that are lethal.

Fish food organisms are altered severely when temperatures approach or exceed 90°F. Predominant algal species change, primary production is decreased, and bottom associated organisms may be depleted or altered drastically in numbers and distribution. Increased water temperatures may cause aquatic plant nuisances when other environmental factors are favorable.

Synergistic actions of pollutants are more severe at higher water temperatures. Given amounts of domestic sewage, refinery wastes, oils, tars, insecticides, detergents, and fertilizers more rapidly deplete oxygen in water at higher temperatures, and the respective toxicities are likewise increased.

When water temperatures increase, the predominant algal species may change from diatoms to green algae, and finally at high temperatures to blue-green algae, because of species temperature preferentials. Blue-green algae can cause serious odor problems. The number and distribution of benthic organisms decreases as water temperatures increase above 90°F, which is close to the tolerance limit for the population. This could seriously affect certain fish that depend on benthic organisms as a food source.

The cost of fish being attracted to heated water in winter months may be considerable, due to fish mortalities that may result when the fish return to the cooler water.

Rising temperatures stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by putrefactive processes, thus affecting the esthetic value of a water course.

In general, marine water temperatures do not change as rapidly or range as widely as those of fresh water. Marine and estuarine fish, therefore, are less tolerant of temperature variation. Although this limited tolerance is greater in estuarine than in open water marine species, temperature changes are more important to those fish in estuaries and bays than to those in open marine areas, because of the nursery and replenishment functions of the estuary that can be adversely affected by extreme temperature changes.

Lead

Heavy metals such as lead are toxic to micro-organisms because of their ability to tie up proteins in the key enzyme systems of the micro-organism. Lead appears in process waste waters from hose production facilities which use a lead sheath cure. The lead is picked up by the wasted steam condensate and contact cooling waters. Loadings in the total process effluent were less than 0.06 kg/kkg of raw material consumption.

Chromium

Chromium appears in the nonprocess discharges mainly from the cooling tower blowdown. Chromium compounds are sometimes used as a corrosion inhibitor and are added to the tower basin or cooling tower makeup. Chromimum was not detected in the process waste water effluent.

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Levels of chromate ions that have no effect on man appear to be so low as to prohibit determination to date.

The toxicity of chromium salts toward aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially that of hardness. Fish are relatively tolerant of chromium salts, but fish food organisms and other lower forms of aquatic life are extremely sensitive. Chromium also inhibits the growth of algae.

In some agricultural crops, chromium can cause reduced growth or death of the crop. Adverse effects of low concentrations of chromium on corn, tobacco and sugar beets have been documented.

Summary of Significant Pollutants

Of the pollutants examined, only COD, suspended solids, oil and grease, lead, and pH are significant characteristics when considering process waste waters. Of the five, suspended solids, oil and grease, lead, and pH must be controlled. The list of control parameters for Subcategories E, F, and G therefore is:

Suspended Solids
Oil and Grease
Lead
pH

Subcategory H and Subcategory I -- Reclaimed Rubber

Review of published literature, EPA documents and industry records, and the findings of the plant visits indicate that the following chemical and biological constituents are pollutants found in measurable quantities from Subcategory H and Subcategory I effluents:

BOD
COD
Suspended Solids
Total Dissolved Solids
Oil and Grease

pH
Temperature
Zinc

Biochemical Oxygen Demand (BOD)

The presence of BOD in Subcategory H process waste waters is due primarily to the use of large quantities of process waters in the digestion of scrap rubber. This waste water is not evolved in Subcategory I production facilities. A second source of BOD is organics found in the condensed vapors collected from both Subcategory H and Subcategory I depolymerization units. Organics found in anti-tack solution discharges contribute additional BOD. The possibility exists that pollutants with a high COD/BOD ratio may be discharged by plants utilizing the wet digestion process. Control of COD by in-plant and end-of-pipe controls will adequately reduce BOD without requiring the additional monitoring costs of both analyses.

Biochemical oxygen demand (BOD) is a measure of the oxygen consuming capabilities of organic matter. The BOD does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes of decomposition exert a BOD, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all inhabitants of the affected area.

If a high BOD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations.

COD

The presence of organics and inorganics in dewatering waste waters will contribute to high COD concentrations in Subcategory H process waste waters. Values for this waste stream are greater than 3,000 mg/l. Other contributors of COD include organics found in condensed vapor streams for depolymerization units and anti-tack solutions used in both Subcategory H and Subcategory I production facilities. Concentrations in these latter sources ranged from approximately 100 mg/l to 340 mg/l. A large portion of this COD is directly attributable to the oil content of these waste streams. However, to prevent excessive discharge of non-biodegradable organics (not attributable to oil and grease) COD shall be monitored and controlled.

Suspended Solids

Suspended Solids (SS) in Subcategory H and Subcategory I are attributable to washdown and runoff from compounding areas, discharges of anti-tack solution, boiler blowdowns, and water treatment wastes. Additional loadings in Subcategory H discharges will result when fiberous stock is fed to the digesters. In this case, the dewatering liquor can contain as much as 10-percent suspended solids.

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography; cooling systems, and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.

Dissolved Solids

Dissolved Solids (TDS) found in Subcategory H and Subcategory I effluents are attributable to nonprocess waste water effluents. These include cooling tower and boiler blowdowns and water treatment system backwashes and blowdown.

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated whereas they could not be in temperate climates. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with cleaness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Oil and Grease

Oil and grease in process waste waters in Subcategory H are primarily attributable to process oil used in the digester process. This oil is carried to the effluent with the dewatering liquor. Sources of oil and grease common to both Subcategory H and Subcategory I are organics scrubbed from vapor streams and lubricating oil leakage from heavy machinery. The oil concentration in the total effluent of the plants visited was less than 10 mg/l. However, company data indicated that concentrations in process streams could be as high as 10,000 mg/l.

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to inhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and coats of water animals and fowl. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

pH, Acidity and Alkalinity

Variations in pH of Subcategory H process effluents is highly dependent on the formula used in digestion. Plant-visit data indicated a minimum pH of 6.0. Industry data indicate a maximum pH of approximately 11.0. Fluctuations in Subcategory I process waste water pH are not expected to be outside the pH range of 6.0 to 9.0.

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

Temperature

In reclaim plants, there are individual waste water streams, such as condenser flows, which have elevated temperatures. However, once combined with other effluents, elevated temperature in the final effluent is not a problem.

Temperature is one of the most important and influential water quality characteristics. Temperature determines those species that may be present; it activates the hatching of young, regulates their activity, and stimulates or suppresses their growth and development; it attracts, and may kill when the water becomes too hot or becomes chilled too suddenly. Colder water generally suppresses development. Warmer water generally accelerates activity and may be a primary cause of aquatic plant nuisances when other environmental factors are suitable.

Temperature is a prime regulator of natural processes within the water environment. It governs physiological functions in organisms and, acting directly or indirectly in combination with other water quality constituents, it affects aquatic life with each change. These effects include chemical reaction rates, enzymatic functions, molecular movements, and molecular exchanges between membranes within and between the physiological systems and the organs of an animal.

Chemical reaction rates vary with temperature and generally increase as the temperature is increased. The solubility of gases in water varies with temperature. Dissolved oxygen is decreased by the decay or decomposition of dissolved organic substances and the decay rate increases as the temperature of the water increases reaching a maximum at about 30°C (86°F). The temperature of stream water, even during summer, is below the optimum for pollution-associated bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant.

Reproduction cycles may be changed significantly by increased temperature because this function takes place under restricted temperature ranges. Spawning may not occur at all because temperatures are too high. Thus, a fish population may exist in a heated area only by continued immigration. Disregarding the decreased reproductive potential, water temperatures need not reach lethal levels to decimate a species. Temperatures that favor competitors, predators, parasites, and disease can destroy a species at levels far below those that are lethal.

Fish food organisms are altered severely when temperatures approach or exceed 90°F. Predominant algal species change, primary production is decreased, and bottom associated organisms may be depleted or altered drastically in numbers and distribution. Increased water temperatures may cause aquatic plant nuisances when other environmental factors are favorable.

Synergistic actions of pollutants are more severe at higher water temperatures. Given amounts of domestic sewage, refinery wastes, oils, tars, insecticides, detergents, and fertilizers more rapidly deplete oxygen in water at higher temperatures, and the respective toxicities are likewise increased.

When water temperatures increase, the predominant algal species may change from diatoms to green algae, and finally at high temperatures to blue-green algae, because of species temperature preferentials. Blue-green algae can cause serious odor problems. The number and distribution of benthic organisms decreases as water temperatures increase above 90°F, which is close to the tolerance limit for the population. This could seriously affect certain fish that depend on benthic organisms as a food source.

The cost of fish being attracted to heated water in winter months may be considerable, due to fish mortalities that may result when the fish return to the cooler water.

Rising temperatures stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by putrefactive processes, thus affecting the esthetic value of a water course.

In general, marine water temperatures do not change as rapidly or range as widely as those of fresh water. Marine and estuarine fish, therefore, are less tolerant of temperature variation. Although this limited tolerance is greater in estuarine than in open water marine species, temperature changes are more important to those fish in estuaries and bays than to those in open marine areas, because of the nursery and replenishment functions of the estuary that can be adversely affected by extreme temperature changes.

Zinc

Subcategory H processes which would result in zinc-laden effluents are not utilized by industry, therefore zinc is not considered a signficant parameter. However, historical data from industry indicate that, with certain digestion formulations, zinc content could be as high as 1,700 mg/l. This same data stated that this zinc was treatable and could be reduced to less than 10 mg/l in the digestion dewatering stream.

Summary of Significant Pollutants

Of the pollutants examined, suspended solids, oil and grease, and pH are significant characteristics when considering process waste waters from Subcategory H and Subcategory I reclaim facilities. COD is an additional contaminant which is significant when considering waste waters from Subcategory H facilities. The recommended list of control parameters for each subcategory is as follows:

Subcategory H	Subcategory I
COD	Suspended Solids
Suspended Solids	Oil and Grease
Oil and Grease	pH
pH	

Subcategories J and K -- Latex-Based Products

Review of published literature, EPA documents, industry records, and findings of the plant visits indicated that the following chemical, physical, and biological constituents are found in measurable quantities in the waste water effluents from facilities manufacturing latex-based products:

BOD
COD
Suspended Solids
Total Dissolved Solids
Oil and Grease
pH
Surfactants
Color
Temperature (Heat)
Chromium
Zinc

The principal differences between the waste water generated in Subcategory J (latex dipping, thread, and porous molds) and Subcategory K (latex foam) plants lie in loadings for BOD, COD, chromium, and zinc.

Biochemical Oxygen Demand

BOD is attributable to the various organic compounds which contact process waste waters. For Subcategory J production facilities, concentrations and loadings are highly dependent on the product washing technique employed. Concentrations range from 130 to 150 mg/l. The BOD in waste water generated in Subcategory K production facilities is again attributable to wash waters, but concentrations are much higher, ranging as high as 4,900 mg/l.

Biochemical oxygen demand (BOD) is a measure of the oxygen consuming capabilities of organic matter. The BOD does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes of decomposition exert a BOD, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all inhabitants of the affected area.

If a high BOD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations.

COD

Moderate to high COD concentrations are present in Subcategories J and K process waste waters for the same reasons as those indicated for the BOD concentration. Concentrations range from 175 to 675 mg/l for Subcategory J facilities and as high as 29,000 mg/l for Subcategory K facilities. EPA is conducting evaluations of COD control technologies and resultant economic impact for possible future amendments to the rubber processing regulations.

Suspended Solids

Suspended solids in Subcategories J and K waste waters result from the contamination of process effluents with uncoagulated latex from washdown and cleanout wastes. Loadings in the effluents depend on washing techniques employed and not on the type of product. Typical values ranged from 80 to over 3,000 mg/l.

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography; cooling systems, and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.

Dissolved Solids

From in-plant data, it was determined that TDS in process effluents from Subcategories J and K production facilities were primarily attributable to the raw intake water and not to process waste water discharges.

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated whereas they could not be in temperate climates. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with cleaness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Oil and Grease

Oil and grease is present at low concentrations in the process waste waters of all types of Subcategories J and K plants. It is attributable to organics used in coagulation agents and wash waters.

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to inhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and coats of water animals and fowl. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

pH, Acidity and Alkalinity

Control and adjustment of pH in process waste waters generated in Subcategories J and K production facilities is often necessary as a prerequisite for the chemical coagulation treatment process. In view of this it is feasible that the uncontrolled effluent pH can vary appreciably and should be limited to an acceptable range.

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

Surfactants

Surfactants will be present in wash waters evolved in all Subcategories J and K production facilities. Surfactants are a primary cause of foamy plant effluents,however, their concentrations in process waste waters are low. Concentrations range from 2 to 6 mg/l.

Color

Color is objectionable from an aesthetic standpoint and also because it interferes with the transmission of sunlight into streams, thereby lessening photosynthetic activity. Some waste streams which contain latex can have appreciable color. Generally, color for latex based industries is associated with suspended solids loadings and can best be monitored by this parameter.

Temperature

Temperature is not a significant parameter when considering process waste streams. Certain wash waters can have a moderately high temperature, but dilution with other effluent streams significantly reduces their impact.

Temperature is one of the most important and influential water quality characteristics. Temperature determines those species that may be present; it activates the hatching of young, regulates their activity, and stimulates or suppresses their growth and development; it attracts, and may kill when the water becomes too hot or becomes chilled too suddenly. Colder water generally suppresses development. Warmer water generally accelerates activity and may be a primary cause of aquatic plant nuisances when other environmental factors are suitable.

Temperature is a prime regulator of natural processes within the water environment. It governs physiological functions in organisms and, acting directly or indirectly in combination with other water quality constituents, it affects aquatic life with each change. These effects include chemical reaction rates, enzymatic functions, molecular movements, and molecular exchanges between membranes within and between the physiological systems and the organs of an animal.

Chemical reaction rates vary with temperature and generally increase as the temperature is increased. The solubility of gases in water varies with temperature. Dissolved oxygen is decreased by the decay or decomposition of dissolved organic substances and the decay rate increases as the temperature of the water increases reaching a maximum at about 30°C (86°F). The temperature of stream water, even during summer, is below the optimum for pollution-associated bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant.

Reproduction cycles may be changed significantly by increased temperature because this function takes place under restricted temperature ranges. Spawning may not occur at all because temperatures are too high. Thus, a fish population may exist in a heated area only by continued immigration. Disregarding the decreased reproductive potential, water temperatures need not reach lethal levels to decimate a species. Temperatures that favor competitors, predators, parasites, and disease can destroy a species at levels far below those that are lethal.

Fish food organisms are altered severely when temperatures approach or exceed 90°F. Predominant algal species change, primary production is decreased, and bottom associated organisms may be depleted or altered drastically in numbers and distribution. Increased water temperatures may cause aquatic plant nuisances when other environmental factors are favorable.

Synergistic actions of pollutants are more severe at higher water temperatures. Given amounts of domestic sewage, refinery wastes, oils, tars, insecticides, detergents, and fertilizers more rapidly deplete oxygen in water at higher temperatures, and the respective toxicities are likewise increased.

When water temperatures increase, the predominant algal species may change from diatoms to green algae, and finally at high temperatures to blue-green algae, because of species temperature preferentials. Blue-green algae can cause serious odor problems. The number and distribution of benthic organisms decreases as water temperatures increase above 90°F, which is close to the tolerance limit for the population. This could seriously affect certain fish that depend on benthic organisms as a food source.

The cost of fish being attracted to heated water in winter months may be considerable, due to fish mortalities that may result when the fish return to the cooler water.

Rising temperatures stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by putrefactive processes, thus affecting the esthetic value of a water course.

In general, marine water temperatures do not change as rapidly or range as widely as those of freshwaters. Marine and estuarine fish, therefore, are less tolerant of temperature variation. Although this limited tolerance is greater in estuarine than in open water marine species, temperature changes are more important to those fish in estuaries and bays than to those in open marine areas, because of the nursery and replenishment functions of the estuary that can be adversely affected by extreme temperature changes.

Chromium

Chromium was not found in the process waste waters generated by any of the Subcategories J and K facilities visited. However, available EPA documents indicate that chromium will be present in process waste waters when chromic acid is used in the form-cleaning solution. The chromic acid is rinsed from the form and consequently enters the plant effluent. For plants utilizing this form-cleaning technique, it is necessary to limit the discharge of chromium ions.

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Levels of chromate ions that have no effect on man appear to be so low as to prohibit determination to date.

The toxicity of chromium salts toward aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially that of hardness. Fish are relatively tolerant of chromium salts, but fish food organisms and other lower forms of aquatic life are extremely sensitive. Chromium also inhibits the growth of algae.

In some agricultural crops, chromium can cause reduced growth or death of the crop. Adverse effects of low concentrations of chromium on corn, tobacco and sugar beets have been documented.

Zinc

Zinc was not found in the process waste waters generated by Subcategory J, facilities that were visited. However, available literature indicates that zinc will be present in Subcategory J process waste waters when zinc nitrate is used as a coagulant agent. However both concentrations and loadings will be very low. The Subcategory J facilities visited either did not use a coagulating agent or used calcium nitrate. When using natural latex, no coagulating agent is apparently needed.

Zinc in Subcategory K facility process effluents is attributable to zinc oxide. The zinc appears in the foam wash waters.

Occurring abundantly in rocks and ores, zinc is readily refined into a stable pure metal and is used extensively for galvanizing, in alloys, for electrical purposes, in printing plates, for dye-manufacture and for dyeing processes, and for many other industrial purposes. Zinc salts are used in paint pigments, cosmetics, pharmaceuticals, dyes, insecticides, and other products too numerous to list herein. Many of these salts (e.g., zinc chloride and zinc sulfate) are highly soluble in water; hence it is to be expected that zinc might occur in many industrial wastes. On the other hand, some zinc salts (zinc carbonate, zinc oxide, zinc sulfide) are insoluble in water and consequently it is to be expected that some zinc will precipitate and be removed readily in most natural waters.

In zinc-mining areas, zinc has been found in waters in concentrations as high as 50 mg/1 and in effluents from metal-plating works and small-arms ammunition plants it may occur in significant concentrations. In most surface and ground waters, it is present only in trace amounts. There is some evidence that zinc ions are adsorbed strongly and permanently on silt, resulting in inactivation of the zinc.

Concentrations of zinc in excess of 5 mg/1 in raw water used for drinking water supplies cause an undesirable taste which persists through conventional treatment. Zinc can have an adverse effect on man and animals at high concentrations.

In soft water, concentrations of zinc ranging from 0.1 to 1.0 mg/1 have been reported to be lethal to fish. Zinc is thought to exert its toxic action by forming insoluble compounds with the mucous that covers the gills, by damage to the gill epithelium, or possibly by acting as an internal poison. The sensitivity of fish to zinc varies with species, age and condition, as well as with the physical and chemical characteristics of the water. Some acclimatization to the presence of zinc is possible. It has also been observed that the effects of zinc poisoning may not become apparent immediately, so that fish removed from zinc-contaminated to zinc-free water (after 4-6 hours of exposure to zinc) may die 48 hours later. The presence of copper in water may increase the toxicity of zinc to aquatic organisms, but the presence of calcium or hardness may decrease the relative toxicity.

Observed values for the distribution of zinc in ocean waters vary widely. The major concern with zinc compounds in marine waters is not one of acute toxicity, but rather of the long-term sub-lethal effects of the metallic compounds and complexes. From an acute toxicity point of view, invertebrate marine animals seem to be the most sensitive organisms tested. The growth of the sea urchin, for example, has been retarded by as little as 30 ug/l of zinc.

Zinc sulfate has also been found to be lethal to many plants, and it could impair agricultural uses.

Summary of Significant Pollutants

Of the pollutants examined, only the following are considered significant characteristics when considering process waste waters from latex-based production facilities:

BOD
Suspended Solids
pH
Chromium
Zinc

Potentially, four of the five must be treated and monitored by Subcategory J facilities. These are:

BOD
Suspended Solids
pH
Chromium

In many Subcategory J facilities, chromium will not appear in the process effluents.

Chromium was not found in the process waste waters of subcategory K facilities, and therefore only four of the five parameters shall be controlled, namely:

BOD
Suspended Solids
pH
Zinc

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

Survey of Selected Plants

Several selected rubber processing plants were visited to provide additional data on the performance of the waste water control and treatment technologies used by the industry. These data collection visits encompassed analysis of process operations, review of water and waste water management programs, and evaluation of waste water treatment facilities. The plants visited were considered to have some exemplary features in their approach to waste water control, treatment, and housekeeping procedures. The plant selections were made on the basis of consultations with industry and trade associations, effluent and treatment data obtained from published literature, EPA records, Corps of Engineers Permit to Discharge Applications, and company historical data on waste water quality and treatment.

As examples of Subcategories E, F, and G industries, plants manufacturing molded, extruded, and fabricated products were sampled. Compression, transfer, and injection molding technologies were represented as well as small and large-sized molded items. The major extruded items such as belting and sheeting were included in the visits. Diverse fabricated products such as hose and rubber footwear as well as rare product areas such as cement dipped goods were studied during the plant visits. In addition all three ranges of plant size (as discussed in the final paragraph of Section IV) were represented by the data-collection plant visits.

As an example of the reclaimed rubber industry, the largest reclaiming plant in the U.S. was visited. Wet digester and pan (heater) reclaim processes are employed. Therefore, this plant is representative of both Subcategories H and I. The wet digester process has exemplary features; physical defibering is carried out and the highly contaminated digestion-dewatering liquor is recycled. In addition vapor vents on both the wet digester and pan processes are condensed and decanted to recover what would otherwise be polluting reclaiming process oils.

Two plants manufacturing latex dipped goods were visited. The products made at the two facilities include surgical gloves, ballons, prophylactics, and finger cots. One plant employed chemical coagulation and settling before discharge to a municipal treatment plant. This primary treatment produced an acceptable effluent for discharge to a municipal treatment system. The second facility utilized a stabilization and settling pond system.

The only significant latex foam plant in the industry was sampled. The treatment facilities used by this plant include chemical coagulation of latex solids and chemical precipitation of the zinc-laden foam rinse waters.

A summary of the products, processes, production capacities, and waste water control and treatment technologies of the exemplary rubber processing plants visited is presented in Tables 18 and 19.

Plant A

This plant manufactures oil seals, 'O' rings, rubber-to-metal molded items, and miscellaneous molded rubber products. The products are made from specialty-type rubbers using compression and transfer molding techniques. Approximately 75 percent are nitrile rubbers, about 20 percent neoprene-type rubber, and 5 percent miscellaneous rubbers. The plant has approximately 46 employees and operates 3 shifts each day, six days per week. The average daily consumption of rubber is 750 pounds, and the weight of salable products averages 450 pounds per day. The material loss is caused by production wastage and rejected products.

Approximately 95 percent of the rubber stock used in the plant is compounded by a supply company. Special recipes and nonstorable stocks are mixed at the plant in a mixing mill. The stock mixed in this mill accounts for the other 5 percent. When operating, this mill uses about 40 gpm of cooling water.

The rubber stock is prepared for processing in a warm-up mill. From the mill the rubber is extruded into a basic shape. This shape can be a strip, a cylinder, or an annulus. The preforms for compression molds are made from these basic components by cutting on a guillotine or fine slicing on a modified meat slicer. The preforms are then loaded into the molds. The molds are placed between the heated plates of the mold presses and the mold presses are hydraulically closed. The hydraulic fluid is oil, at approximately 2,000 psi, and oil leaks are common. The oil leakages are generally trapped in a small oil pit from which the oil is periodically removed and reclaimed by decanting, drying and filtering. Large oil spills overflow this pit and enter the plant drain. Most molds are heated with steam at 350°F (125 psi) although a few older molds are generally slabs of rubber stock which are loaded into the transfer section of mold. The mold is closed in the hydraulic press. The rubber wastage on a transfer-molded item is higher than for compression molding but the labor requirements are less.

The molded items are deflashed in a wheelabrator machine. This freezes the item with liquid nitrogen, making the rubber brittle, and then blasts it with small steel shot. The rubber fines and shot are separated and the fines and dust are collected in a bag collector and

Plant	Product	Process	Production Capacity kg/day (lb/day)	Control Measures	Primary Effluent Treatment	Secondary Effluent Treatment
Subcategory E - Small Plants						
A	Seals, General Molded Items	Compression and Transfer Molding	340 (750)	Most drains in milling and curing areas are blocked.	None	None. Direct discharge to stream.
B	Cement Dipped Gloves	Cement Dipping	500 (1100)	No floor drains	None	None. Direct discharge to stream.
Subcategory F - Medium Plants						
C	Molded Sport Grips, Rubber-Metal Bonded Items	Compression, Transfer and Injection Molding	8,600 (19,000)	Most drains in compounding, milling, and curing areas are blocked. Dry dust collection devices.	None	None. Direct discharge to stream.
D	Hose, Various Sizes	Extrusion and Fabrication	9,000 (20,000)	Most drains in compounding and milling areas are blocked.	None	None. Direct discharge to stream.
Subcategory G - Large Plants						
E	Belting and Sheet Rubber	Extrusion	26,000 (58,000)	In-plant containment of oil leaks and spills.	None	None. Direct discharge to stream.
F	Large Seals and Weather-Stripping	Molding and Extrusion	26,000 (58,000)	Most drains in compounding, milling, and curing areas are blocked.	Gravity oil separators and holding pond.	None. Direct discharge to stream.
G	Hose, Various Sizes	Extrusion and Fabricated	73,700 (162,500)	Blocking of some floor drains and use of dry clean-up methods.	None	None. Discharge to municipal treatment system.
H	Canvas and Cement Dipped Footwear	Molding, Fabrication and Cement Dipping	120,000 (265,000)	In-plant containment of oil leaks and spills.	Gravity oil separation, and chemical coagulation and clarification of latex-laden wastes.	None. Direct discharge to stream.

[1] The definition of the plant sizes is based on total raw material usage: Small plants, less than 3,720 kg/day (8,200 lb/day); Medium plants, 3,720-10,430 kg/day (8,200-23,000 lb/day); and Large plants, greater than 10,430 kg/day (23,000 lb/day).

Table 18: Waste Water Control and Treatment Technologies at Subcategories E, F, and G Plants with Exemplary Programs

	Subcategory H Wet Digestion Rubber Reclaiming	Subcategory I Pan (Heater), Mechanical, and Dry Digestion Reclaiming	Subcategory J Latex-Dipped, Latex Thread, and Latex-Molded Products		Subcategory K Latex Foam
Plant	I	I	J	K	L
Product	Reclaimed Rubber	Reclaimed Rubber	Ballons, prophylactics, and finger cots.	Surgical gloves, hot water bottles, rubber syringes, and pharmaceutical items.	Foam mattresses and pillows.
Process	Wet Digestion	Pan (Heater)	Latex Dipping	Latex Dipping Compression Molding	Talalay foam process
Production Capacity kg/day (lb/day)	56,000 (123,000)	45,000 (100,000)	4,300 (9,500)	900 (2,000)	90,000 (200,000)
Control Measures	Physical defibering and return of process oils and digester liquor.	Return of process oils.	Few in-plant drains. Minimal water usage for tank cleaning.	Few in-plant drains.	Countercurrent foam rinse system.
Primary Effluent Treatment	Oil separation and recycle of process oils and digester liquor.	Oil separation and recycle of process oils.	Settling ponds.	Coagulation and clarification of latex solids.	Latex waste chemical coagulation and clarification. Zinc precipitation and clarification.
Secondary Effluent Treatment	None. Direct discharge to stream.	None. Direct discharge to stream.	Settling pond effluent discharged to stream. Evaporation pond for latex waste waters.	None. Discharge to municipal treatment system.	Proposed: equalization, carbonate precipitation, and filtration of present primary effluent.

Table 19: Waste Water Control and Treatment Technologies for Subcategories H, I, J, and K Plants with Exemplary Features

drummed. The steel shot range in size from seven to twelve-thousandths of an inch. In cases where the shot would blind small crevices of the molded items, manual deflashing is carried out. Manual deflashing consists of spinning the item on a chuck and grinding off the flash with a fine sandstone.

The molded products are inspected, packaged and shipped. Rejected items are removed as solid waste.

Metal parts for rubber bonding are first degreased with perchloroethylene vapor. The waste, grease-laden solvent, is drummed and removed as solid waste. After degreasing the bonding surface is sand blasted in a sand blasting drum to impart a rough surface. The prepared bonding surface is painted with a bonding agent (rubber cement) and the preform is attached. The metal preform item is molded in a similar manner to the all-rubber items.

Occasionally the molds require cleaning. This is carried out by a dry honing process which consists of blasting the molds with fine glass beads.

Waste waters are generated by: cooling waters from the compounding mill, the warm-up mill, the extruder and the nitrogen compressor, blowdown from the boiler (approxiately twice a day, 5 gallons each time), and regeneration wastes from the boiler feed water deionizer (approximately 8 lbs sodium chloride per day). The steam condensate recycle rate is high, approximating 100 percent.

Contaminants, oil and grease, and minor quantities of suspended solids, enter these utility streams at unprotected floor drains. The raw plant effluent, including utility streams, has oil concentrations on the order of 40 mg/l and negligible suspended solids.

Plant B

This plant manufactures electrical gloves and shoulder-length sleeves via a dipping process in solvent-based rubber cement. The principal raw material is natural rubber, although EPDM rubber gloves are being developed. The solvent is a naphtha type compound. The material consumptions average 1,100 pounds of rubber and 1,100 gallons of solvent per day. Each pair of gloves requires approximately one pound of rubber. The sleeves require more rubber. The plant operates 24 hours per day, 7 days a week.

The rubber, pigments, and vulcanizing agents are compounded on a 2-roller mill and are sheeted out to approximately one-half of an inch in thickness. The mill uses once-through cooling water. The sheeted rubber is fed into a guillotine where it is chopped into three-inch squares, which are weighed into a container.

The rubber is transported to the cement mixing room where the rubber is dissolved in solvent in a blend tank. The mixed rubber cement is transferred from the blend tank to a storage tank where it is stored before the dipping operation. Cements with different recipes and colors have their own storage tank systems. The naphtha solvent is pumped from outside tanks to the blend tank via two solvent pumps. Solvent spills are very infrequent because of fire protection requirements. The mixing room is fitted with an automatic fire system which is designed to shutdown the pumps, close the doors of mixing room, and fill the room with carbon dioxide gas to extinguish a fire.

The gloves are dipped onto glazed porcelain forms in a cement dipping room. The forms are held on a rack by their bases and dipped between 20 and 30 times to build up the glove thickness. Each rubber layer is allowed to drip-dry between dips. The total dipping-drying operation takes about 48 hours. The temperature and humidity of the air in the drying room is controlled by an air quality control system. Exhausted air is used to heat incoming air. No air pollution control devices are believed necessary. The air quality control system discharges condensation at times when the air requires dehumidification. This condensation is pure water.

After drying, the base of the glove is trimmed by a cutting wheel and the cuff bead is formed by rolling up the cuff. Labels indicating the brand and size are attached to the glove cuffs with rubber cement.

The gloves still on the forms are loaded into an open steam autoclave for vulcanization. The forms are allowed to adjust to the residual temperature of the autoclave before the steam is applied. The gloves are cured with 35 psig steam (temperature 280°F) for 40 minutes. The forms plus gloves are removed from the autoclave and allowed to cool. During the curing operation, the steam condensate that accumulates in the autoclave is discharged for seven seconds every two minutes under pressure to the plant drain. The condensate picks up organics from the curing gloves. The COD of this steam is approximately 800 mg/l. The flow, however, is extremely low, about 3 gph on average.

When partly cooled, the gloves are dipped in a talc slurry and allowed to dry. The talc slurry is a closed system. Makeup talc and water are added to the slurry dip tank. The dry gloves are stripped manually from the molds and placed in a tumbler with a small amount of talc powder to coat the inside of the gloves.

The procelain molds are cleaned periodically by manual scrubbing. The scrubbing waste water and rinse waters are containerized and hauled from the plant by contract haulers.

The gloves are visually inspected for flaws. Gloves which pass the visual inspection are tested for their electrical resistance in a water tank. The tank overflow, low in flow and uncontaminated, is discharged to the plant effluent. Gloves which fail the visual inspection or the resistance test are sold as industrial gloves.

The green bladders are cured in steam heated stand-presses. These presses are mechanically closed and the whole bladder building area is "dry" and oil free. Steam condensate from the presses is recycled. Metal parts for molding to the bladders are first degreased using a closed trichloroethylene system, sandblasted, and sprayed with rubber cement as a bonding agent.

Plant C

This plant produces molded rubber grips for golf clubs, tennis rackets, baseball bats and tools. Another major type of product is bladders for air-activated brakes and clutches. The types of rubber used are natural rubber (approximately 75 percent) and various synthetic rubber (about 25 percent). The daily quantity of compounded rubber stock used to manufacture the grips is 17,000 pounds, and to build the bladders is 2,240 pounds.

The rubber stock is compounded in a separate building. Stock is also prepared for a sister plant in another location which does not have its own compounding facilities. The grips require stock of various colors, including black. Carbon black is not added at the plant; instead, black master batch rubber is used. The bladders are made solely from black rubber. The compounding facilities consist of a No. 3 Banbury mixer, two intermediary or storage mills, a 4 roll, Z-calender mill, a calendered stock sprayer cooling tank, a zinc stearate dip tank, and a stock drying tower. In addition, a small calender is used to prepare stock for the pneumatic bladders. All cooling water, with the exception of the spray cooling tank, is provided by a closed loop chilled water system (water at 46°F). The spray cooling water is discharged untreated to the main plant sewer. The dust collection device for the Banbury mixer is a wet scrubbing roto-clone. Because of poor performance and maintenance problems, the roto-clone is not operated and is to be replaced with a bag collector device.

The rubber grips are molded by compression, transfer, and injection molding equipment. The injection mold extruder is cooled by its own closed loop chilled water system. The presses for the compression and transfer molds are hydraulic oil activated. Oil leaks occur and are soaked up with absorbent granules. No open floor drains exist in the molding area.

The molded rubber grips are deflashed by hand using a trimming knife before painting and final preparation. The grips are dipped in paint and hung to dry. Paint drippings and spills are contained since no floor drains exist in this area. The paints are mixed in a closed room to contain solvent odors. There are no floor drains in the paint mixing area. There are potential air pollution problems in this area. A control system has yet to be selected.

After painting, the grips are buffed to impart smoothness and remove the last traces of the flash. Dry bag collectors are used to trap the airborne buffing dusts. The molds are periodically cleaned by blasting with glass beads in a closed hood.

The pneumatic bladders are built on building machines in a manner similar to tire manufacture. Cord fabric is purchased from an outside supplier.

The green bladders are cured in steam heated stand-presses. These presses are mechanically closed and the whole bladder building area is "dry" and oil free. Steam condensate from the presses is recycled. Metal parts for molding to the bladders are first degreased using a closed trichloroethylene system, sandblasted, and sprayed with rubber cement as a bonding agent.

Approximately 80 percent of the steam used in the plant is recycled to the boiler as condensate. The boiler feed water is not softened to demineralized. Instead, treatment agents are added to the feed water to eliminate scale build up. The only process-associated discharges to the plant sewer are cooling water for the service air compressors and cooling water for the hydraulic oil pumps, in addition to the calendered stock spray cooling water. The overflow from the plant's septic tank systems is routed through the main plant sewer.

Extruded oil used in the mill room and machinery oil stored in the compressor area have on occasion entered the effluent via floor drains. It is the company's belief that these drains can be closed and the oil involved stored elsewhere.

The plant's effluent has good COD (50 mg/l), suspended solids (13 mg/l) and oil (7 mg/l) levels. It is believed that the oil can be further reduced with good housekeeping and the blocking of offending floor drains.

Plant D

This plant manufactures several types of reinforced hose. The outside diameters of the hoses range from approximately 3/4 inch to six inches. Hoses are made on both rigid and flexible mandrels. Most sizes of hose can be made in lengths up to about 100 meters. In addition, small bore hose can be produced in continuous lengths. Hose is reinforced with yarn and wire using braided and spiral winding methods. Vulcanization is carried out by both cloth wrapped and lead-sheathed techniques. The plant consumes appoximately 20,000 pounds of raw materials each day. It operates 24 hours per day for five days each week and employs 530 people. The plant is in a rural area with a total area of 120 acres, 7.3 acres of which consist of the roofed plant area.

The plant water is supplied by 3 wells owned by the plant. The capacities of the wells are 500, 250 and 250 gpm, respectively. The water from the 500-gpm well is chlorinated for domestic, sanitary and process usage in order to minimize the activity of ferro-bacteria.

Rubber stock is prepared in the compounding area. The recipe is varied to suit the particular service requirements of the hose. The rubber ingredients are mixed in a Banbury mixer and sheeted out on a roll mill. The sheet rubber is dipped in soapstone slurry and hung to drip and dry. An open drain beneath the soapstone drip area collects soapstone drippings which are discharged to the plant's final outfall. In addition, the cooling water from the mills is discharged into an open drain which can readily be fitted with a collar, or the opening can be completely sealed to prevent the entry of oil and grease to the drain.

The tube component of the hose is extruded and cooled in an open tank by direct contact with cooling water. From the cooling tank, the tube is passed through a tank of anti-tack agent ("Acrawax"). Soapstone solution is not used for application because its anti-tack property is more permanent and would adversely affect the future bonding of the tube to the other components of the hose. The overflow from the cooling tank and drippings from the anti-tack system are discharged to the plant's final outfall. The floor drain to which the overflow cooling water is discharged could be equipped with a collar or completely sealed. The extruded and cooled tube is coiled on a form in a helix.

Hose tube that requires rigid mandrel support is unwound from its coil and pulled onto the rod-like mandrel in lengths of approximately 50 meters. Tube to be supported on flexible mandrels is extruded onto the rubber- or plastic-coated mandrel at the extruder. A release agent is sprayed between the tube and the mandrel to facilitate subsequent removal of the mandrel. Some small bore hose is sufficiently rigid not to require a mandrel.

The hose tube is braided or spirally wound with yarn or wire. The yarn and wire are manufactured by supply companies and are received ready for use. The "reinforcing" operations are "dry" and no floor drains exist in this area. The outer cover is extruded into the reinforced hose before curing.

Shorter lengths of hose are sheathed with lead in a lead press. The lead sheath is cooled directly with water. The sheathed hose is placed in a long autoclave which is heated directly with steam. After curing, the lead sheath is stripped from the hose and re-cast into billets to feed the lead press. The cured hose is removed from the mandrel by water or air pressure, inspected, and coiled for shipment. Larger sizes of hose are tape-wrapped and charged into a direct-steam heated autoclave. After curing the tape is removed from the hose and the mandrel removed by water or air pressure or a mechanical pulling technique. The condensate from the lead-sheathed curing autoclaves contains lead (70 mg/l) and is discharged directly.

Cooling waters from the mills, tube extruders, and lead cooling processes are discharged via sumps to the final outfall. Periodically the sumps are cleaned of accumulated oils and solids. The air compressor condensate passes through an oil trap drum. The drum is periodically skimmed of oil. The combined waste waters flow over a V-notch weir into a small creek to the river.

An outside drum storage area contributes to the oil in the plant's waste water during storms. This area is unroofed and is used to store new, partly full, and empty drums of various oils and chemicals. The storm water passes through a sump before its discharge to the final outfall but the sump is not regularly cleaned and oil seepage occurs.

The plant's combined effluent has the following quality: COD, 20 mg/l; suspended solids, approximately 1 mg/l; and oil and grease, less than 1 mg/l.

Duplicate samples analyzed by Plant D yield a different description of the effluent quality: COD, 284 mg/l; suspended solids, 10 mg/l; and oil and grease, 5.9 mg/l. Long-term data supplied by the plant on their own samples indicate COD, 20.5 mg/l; suspended solids, 4 mg/l; oil and grease 16.5 mg/l; flow, 0.085 MGD; production, 41,407 lbs/day (monthly averages for the period of contractor sampling).

Plant E

This plant produces both cured and uncured sheeted rubber, metal-reinforced heavy service conveyor belting, and fabric reinforced conveyor belting. The weight of finished products averages approximately 52,000 pounds per day. Raw materials consumed each day amount to 52,000 pounds of compounded rubber and 6,000 pounds of fabric. An additional 2,000 pounds per day of miscellaneous material, such as reinforcing wire and packaging material is consumed. The plant is located in a rural community and employs approximately 183 production and management personnel. The plant operates three shifts per day, seven days per week.

No compounding is done by this plant. Rubber stock is compounded at a nearby company owned facility. The fabric consumed by the plant is dipped in latex and friction-coated with rubber at another location.

The compounded rubber stock is prepared for processing on four warm-up mills. Rubber from these mills is formed into sheets in an extruder-calender machine. The temperatures of the roller mills and extruder-calender are controlled by recirculated cooling water and hydrotherm cooling systems. The sheeted rubber is cooled in a water spray cooling tank. The contact cooling water overflows and is reused in the plant's main recirculated cooling, water system. After cooling the sheeted rubber is dipped in soapstone solution to prevent it from sticking together during storage. Curbing and a floor sump have been installed in the soapstone dip area to contain accidental spills, and overflows. The sump is emptied into a portable tank and removed by a private hauler.

The dipped sheet rubber is passed over air vents to dry, and is then rolled up into large rolls. The sheeting operation described above is performed eight hours each day, five days per week; it uses 60-70 percent of the cooling water circulated through the plant.

Once sheeted, the rubber is sold as uncured or cured sheeted rubber, or conveyor belting.

Curing of sheeted materials is performed in presses, rotacures, or hot air curing ovens. The rotacure system employs a combination of steam, cooling water, and electric heaters to cure sheeted rubber under prescribed conditions. Both the steam and cooling water are recycled. Presses employ steam and a hydrotherm cooling system to cure the sheet. The third system is a gas fired hot air cure. This technique does not require steam or cooling water.

In addition to the production of sheeted rubber, the plant also builds the body plies, or carcasses, used to make conventional fabric-reinforced conveyor belting. Fabric, which has already been frictioned with rubber, is shipped to the plant. This material, which is single ply and has a maximum width of approximately 55 inches, is used to build carcasses of multiple ply thicknesses and various widths up to approximately 128 inches. Once built, this belting is rolled in fabric cloth and sent to another plant to have an upper and lower layer of rubber applied to the fabric. Completed belts are frequently returned to the plant for curing.

Waste waters are generated by the cooling system overflows, zeolite softener regeneration wastes, boiler blowdown, plant runoff, hydrotherm systems, air conditioning systems, and domestic sources.

The principal waste water problems at the plant originate with the hydraulic oil systems for the curing presses. Oil leaks from the oil systems are frequent. Curbing and oil sumps have been installed to contain such leaks. Periodically the collected oil is removed from the sumps and drummed prior to disposal. The oil leakages from the hydraulic oil systems have in the past been so severe and uncontained that the ground beneath the plant contains large amounts of oil. Since the water table under the plant is very close to the ground surface, sumps are also used to control the seepage of oil water into the plant basement. The oil is periodically removed from these basement sumps and drummed.

It can be said that, by utilizing the oil containment practices described above, the plant is approaching zero discharge of process waste waters. It should be noted, however, that this plant has neither rubber compounding nor process oil storage facilities.

Plant F

This plant manufactures rubber pipe seals, weather stripping, and rubber-to-metal molded items. The plant employs 377 factory personnel and operates 24 hours per day, seven days per week. The daily consumption of rubber is 22,200 lbs. Other raw materials include carbon black (29,400 lbs/day), chemical compounds (5,100 lbs/day), and oils and wax (840 lbs/day).

Rubber stock is compounded in a Banbury mill. Depending on the amount of stock being processed, both nonreactive and reactive stocks are compounded. During normal operations, however, the stock is compounded only once (reactive stock) with all the compounds, including vulcanizing agents, added at the same time. The material is batched off in sheets, dipped in soapstone, air dried, and placed in temporary storage.

Weather stripping, pipe seals, and molding plugs are formed by extrusion in either short or long barreled extruders. Short barreled extruders require warm-up and strip feed mills, whereas long barreled extruders do not. All extruders are temperature controlled; both steam and cooling water are used. The extruded items are cooled, dipped, cut, and placed in autoclave pans in preparation for curing. Extruded items are cured in autoclaves with 100 psi steam.

The final form of the weather stripping product is created by linking several pieces of weather stripping and using a transfer molding technique to mold the corners, thereby joining the separate components. The rubber corners are cured by circulating hot oil or steam in the cavities of the molding presses. Flash is removed manually. Before curing, the molds are wiped with a lubricating liquid to ensure proper release from the mold.

The ends of pipe seal rubber are cemented together to form the large O-ring type pipe seals. The operation is carried out in an electric press. When bonding rubber to metal, the metal part must first be degreased, using trichloroethylene in a closed system, and then sprayed with an adhesive. The rubber is transfer-molded to the metal part.

Waste waters generated at this plant include boiler blowdown, cooling tower and chiller water overflow, once through cooling water, leakages, from the various hydraulic and curing oil systems, and spillages and drippings of lubricating solutions.

The greatest problem currently facing the company is storm runoff. A recent large spillage of oil convinced company officials that control and treatment of this type problem was a necessity. Sewer lines are still coated with oil from the spill. To control this problem, two gravity separators collect all water leaving the plant including runoff. Oil storage pumping stations are covered. Drip pans are provided for oil transfer lines.

Steam condensate from the autoclaves flows into a final holding lagoon and is not discharged. Boiler treatment and blowdown wastes and one group of roof drains flow into a detention pond to settle oil and solids. From the detention pond, the water is siphoned from below the surface and flows to a separator where any residual oil is removed.

The resultant effluent concentrations are approximately: COD, 100 mg/l; suspended solids, 40 mg/l; and oil, 3 mg/l.

Plant G

This plant manufactures braided and spirally wound, reinforced rubber hose as well as plastic-based hose. Both metal and fabric reinforcing components are used. Total raw material consumption for rubber products is approximately 162,500 pounds per day. The plant operates 24 hours per day, 5 days per week.

Three different production processes are employed. Industrial hose is produced by compounding, extruding, and pan curing. Hose, which requires curing inside a mold, is produced by compounding, extruding, encasing hose in lead, and curing. Preformed hose is produced by compounding, extruding, forming, and curing.

All rubber and compounds are mixed in one of four Banbury mills. The compounded material is dropped from the Banbury where it is sheeted out, dipped in a recirculated soapstone solution, air dried, and piled on skids to await further processing.

To make the hose, compounded rubber is extruded into a tube. Both long and short barreled extruders are employed at this plant. Short barreled extrudes require warm up and strip feed mills, whereas long barreled extruders do not. The tubing is cooled, dipped in a zinc stearate lubricating solution and placed in a temporary storage.

Reinforcing material is applied to the outside of the tube by braiding or winding machines. No water is used in this area. Finally, the outer covering is extruded onto the reinforced rubber tubing.

Lead sheathing can be extruded onto the hose in a solid or molten state. The lead covered hose is wrapped onto large spools. The lead-sheathed hose is filled with water to apply pressure on the inside of the hose before it is cured in steam heated autoclaves. After curing, the lead covered hose is cooled and the lead covering is removed mechanically and recycled to the sheathing process. The water is released from the inside of the hose. The hose is hydraulically tested with water before final storage and shipment. The hydraulic test water is discharged.

Industrial hose which does not require molding is pan cured. The stock is placed in pans and cured in autoclaves. Preformed hose is made from uncured or semicured hose which is cut to length, placed on a form to give it the proper shape, and cured in autoclaves.

Waste waters from this plant arise from the use of water as a lubricant, spillages of other lubricating or anti-tack solutions, condensate from autoclaves, hydraulic testing water, pressure-water for the curing operation, boiler blowdown, softener backwash, and cooling system overflows. No steam condensate is recycled.

A municipal system receives all the waste waters from this plant operation. No pretreatment of waste is practiced.

The effluent quality is comparable to other plants in this industry group and is acceptable for publicly owned treatment works. The effluent levels are approximately: COD, 300 mg/l; BOD, 30 mg/l; suspended solids, 40 mg/l; and oil, 5 mg/l.

Plant H

This plant produces canvas footwear, cement dipped boots, and foam rubber for carpet underlay and shoe innersoles. Daily raw material consumption amounts to approximately 265,000 lbs per day of rubber compounds.

Canvas shoes are the result of many different production operations including compounding of rubber stocks, molding of the soles, extrusion of the other various rubber components, cutting and fabricating of canvas parts, construction of all these items into the final product, and curing of the final product.

The rubber used in this plant is compounded with other chemicals in six Banburys and sheeted out in mills. The compounded sheeted stock is cooled on six cooling conveyers employing three different cooling techniques: a water spray, a cooling water tank, and water evaporation. Three cooling conveyers employ a water spray against the bottom of the conveyer belt carrying the rubber stock. On two cooling conveyers the rubber is completely immersed in water. The final system employs a spray directly onto the rubber. Evaporation of this water supplies the bulk of the cooling. After cooling by each of the three techniques, the rubber is rolled onto large rolls.

The innersoles of the shoes are cut with dies from sponge rubber sheets. The sponge rubber sheet is prepared by extruding or calendering rubber stock, containing blowing agents, into sheets. The sheets are continuously cured in presses.

The soles are either cut from uncured rubber sheets, or formed in compression or injection molds. The technique employed depends on the final product and the technology available.

Compression molding technology is older and requires more manual labor than the completely automated injection technique. Its advantage is in the ability to mold many different colors simultaneously. Oil supplies the hydraulic pressure for both molding techniques. The curing presses are heated electrically.

After curing the molded soles are buffed to remove the flash. A coat of latex is applied to the sole after which it is dried in an electric oven.

Canvas uppers for shoes are made from two or three ply material. Canvas material arrives at the plant as single ply sheets in various colors. Latex is applied to the sheets; the sheets are then pulled together and passed over steam heated drums. The sheets are stacked and then cut to the proper dimensions using a die and press. The various pieces composing the canvas portion of the shoe are stitched together in making lines.

The shoe is fabricated from the various components on a form called a last. The canvas top is cemented at its edges and placed over the last. The innersole is then applied. Before the toe pieces, the boxing, and the outer sole are applied, the bottom of the innersole and canvas is dipped in a latex solution. The latex is used to hold the entire shoe together. Next the sole, toe and heel pieces, and boxing are applied. The finished uncured shoes are inspected and placed on curing racks. The shoes are cured in autoclaves in an ammonia atmosphere. Approximately 10 lbs of ammonia is used per autoclave per cure. At the end of the curing process, the autoclave is vented to the atmosphere. The need to collect and control the ammonia contained in the autoclave ventings is being investigated.

Cement dipped boots involve a slightly different building process. The pieces of fabric forming the carcass of the boot are applied to forms which are dipped in a rubber cement solution, dried, cured, and finally packaged.

Process waste waters from this plant consist of latex tank cleaning waste waters, oil dripping and leakage from heavy processing machinery, and discharges from wet dust collectors. Waste latex, or latex remaining in drums that can no longer be used, is removed from the plant by a private contractor. Latex rinse waters, used to remove residual quantities from the latex drums, are coagulated with ammonium alum and settled out in a retaining basin. Clarified water is allowed to overflow to the river. Coagulated rubber is removed from the basin whenever necessary. The washing operation is periodic, occurring approximately 10 to 12 times per 24-hour day. Discharges from the basin occur for a total of approximately one hour each day. Plant personnel are considering modifying the system by adding mixers to the basin. There is currently insufficient mixing in the basin and large quantities of latex remain uncoagulated and leave the basin via the overflow. This latex eventually coagulates in the overflow drains causing them to clog periodically with solids.

Drippings from open gears and leakages from motor and mill bearings cause the spillage and leakage of oil and water to accumulate in the mill and heavy machinery basins. The plant has installed two systems to cope with these problems. Motor areas are diked and equipped with a 300-gallon oil collection sump. Mill basin drains have been intercepted so that leakages that enter these drains flow via a trough into a holding tank. Oil is removed from the tank by a stainless steel belt. Plant personnel estimate the retention time in the tank to be 72 hours. When operating, the unit has an overflow rate of 1-2 gpm. Oil picked up by the belt passes into a waste oil storage tank which is periodically emptied and the waste oil drummed.

Each Banbury line is equipped with a wet dust collector. In addition, two wet collectors control particulate pollution in the buffing operation by collecting sole flash. Flow from these collectors goes untreated to the outfall.

The plant effluent quality is approximately: COD, 76 mg/l; BOD, 6 mg/l; suspended solids, 29 mg/l; and oil, 7 mg/l.

Plant I

This plant manufactures reclaimed rubber from whole tires and miscellaneous rubber scrap. Daily raw material consumption includes 175,000 lbs of whole tires (approximately 8,750 tires) and 127,000 lbs of miscellaneous scrap, the bulk of which is inner tubes. Total reclaim production is currently 271,000 lbs per day. Two reclaim processes are employed, one for tires based on the conventional wet digestion process, and a second process used primarily for scrap inner tubes, called pan or heater process.

In the digester process, whole tires are brought to the plant and stored in open areas. Plant personnel manually separate steel belted and studded snow tires from other conventional tires. Currently, tires containing steel (other than bead wire) cannot be processed by this plant and are sent to dumps. Tires to be processed are passed through a magnetic sensing device which removes any steel belted or studded tires not previously removed.

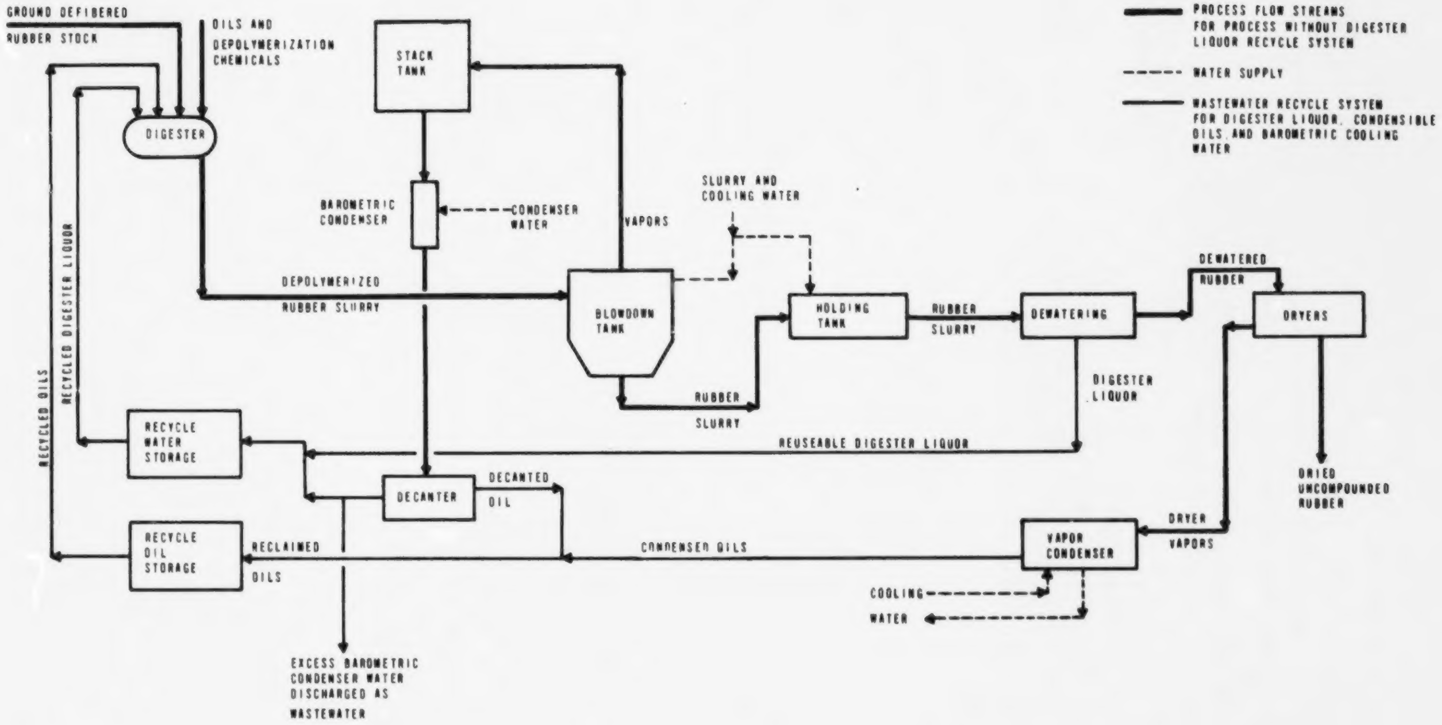
Cracker mills grind and break up the whole tire. The ground tires are screened and oversized particles recycled to the mills. After the first milling, an operator removes large sections of the bead wire. A magnetic separator removes the smaller sections of bead wire which pass through the screens with the ground rubber. The particles of rubber which still contain fiber from the cords and belts are further ground in stoners (fine grinding equipment) and hammer mills. The additional grinding facilitates the removal of the fibers by air separation techniques. Separated fiber is baled and sent to landfill sites.

A final grinding operation reduces the rubber particle size to 20 mesh. This grinding is necessary for the removal of the final traces of fiber from the rubber product. The reduced particle size also reduces the amount of oil necessary to devulcanize the rubber in the digestion step.

The fine, fiber-free particles are mixed with oil, water and chemicals (typically a calcium-based or formaldehyde digestion solution) and fed to a digester where the rubber is devulcanized. The digestion liquor is heated with steam injection. From the digesters, the resultant slurry passes to a blowdown tank. Quench or cooling water is added to the slurry in the blowdown tank. From the blowdown tank, the rubber slurry passes to a holding tank, where additional water is added before dewatering on a screen and finally in a dewatering press. The dewatered rubber is dried in screw dryers using recirculated steam. The liquor from the screen and press pass through a 200-mesh screen where fine rubber particles are recovered. The dewatering liquor is recycled to the digesters. Vapors from the blowdown tank are trapped and condensed in a barometric condenser. Vapors from the dryers are similarly condensed. Oils are separated from the condensed vapors in a decant tank and are returned to the digestion stage where they are reused.

The recycle system for the dewatering liquor and the reclaimed process oils is shown in Figure 9. The waste overflow from the decanter is approximately one-third of the total of the waste dewatering liquor plus the vapor condensate without the recycle system.

The dried devulcanized rubber is mixed with other compounds including carbon black and oil. The mixing takes place in an internal mixer-extruder. Compound usage follows a specific recipe related to the


GROUND DEFIBERED
RUBBER STOCK
OILS AND
DEPOLYMERIZATION
CHEMICALS
DIGESTER
STACK
TANK
BAROMETRIC
CONDENSER
CONDENSER
WATER
VAPORS
DEPOLYMERIZED
RUBBER SLURRY
BLOWDOWN
TANK
SLURRY AND
COOLING WATER
HOLDING
TANK
RUBBER
SLURRY
DEWATERING
DEWATERED
RUBBER
DRYERS
DRIED
UNCOMPOUNDED
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SLURRY
DIGESTER
LIQUOR
REUSEABLE DIGESTER LIQUOR
RECYCLED OILS
RECYCLED DIGESTER LIQUOR
RECYCLE
WATER
STORAGE
DECANTER
DECANTED
OIL
RECYCLE
OIL
STORAGE
RECLAIMED
OILS
CONDENSER OILS
DRYER
VAPORS
VAPOR
CONDENSER
COOLING
WATER
EXCESS BAROMETRIC
CONDENSER WATER
DISCHARGED AS
WASTEWATER
PROCESS FLOW STREAMS
FOR PROCESS WITHOUT DIGESTER
LIQUOR RECYCLE SYSTEM
WATER SUPPLY
WASTEWATER RECYCLE SYSTEM
FOR DIGESTER LIQUOR, CONDENSIBLE
OILS AND BAROMETRIC COOLING
WATER

FIGURE 9: WASTEWATER RECYCLE SYSTEM FOR THE WET DIGESTER RECLAIM PROCESS

end-product use of the reclaim. Finally the compounded reclaim is milled into sheets to form the final product.

The pan or heater process, which is used for miscellaneous rubber scrap but primarily for inner tubes, differs from the wet digestion process described above in that no fiber separation equipment is needed and devulcanization of the rubber is carried out via a dry process.

Operators remove metal, such as inner tube valves, from the scrap rubber. Conveyors carry the metal-free rubber to a cracker mill where it is ground and screened. The rubber particles are mixed with oil and other chemicals, placed in bins, and devulcanized in a large horizontal heater. After devulcanization, the rubber is milled into sheets to form the final product.

Process waste waters from the wet digester process arise from the dewatering process and the various vapor condensers in the digester process area. Discharge of the waste water from the dewatering press has been eliminated in the past year by recycle of the water to the digestion stage. Oils condensed from the vapor streams are separated from the water in a decant tank and fed back to the digester. Water from the decant tank is recycled to the digestion makeup stage when possible or discharged as a waste water. Process waste waters from the pan devulcanizer process are caused by the condensation of vapor streams. These are combined with digester vapor streams and decanted together with the digester stream. The reclaimed oils are recycled to the wet digestion process.

The process waste waters which cannot be recycled are discharged. The resulting plant effluent quality is approximately: COD, 110 mg/l; suspended solids, 50 mg/l; and oil 10 mg/l. It is believed that these waste waters would be readily treated in a municipal sewage treatment system.

Plant J

This plant produces balloons and prophylactics. Finger cots are also produced, but not on a continuous basis. The plant is located in a rural area and employs approximately 50 people. Natural latex is the primary raw material for all dipped items. No other types of latex are consumed. Approximately 2,650 lbs latex is used to produce 3,800 gross of prophylactics per day; 10,170 gross of toy balloon are likewise produced from 6,810 lbs of latex. Because of the proprietary nature of the production equipment and the highly competitive nature of the operation, inspection of the processing lines was not permitted.

The natural latex arrives by tank car and is pumped to holding tanks. The latex recipe is compounded in a water-cooled tank from which it is pumped into drums together with varying quantities of dilution, or makeup, water depending on the end-use. This drummed latex mixture is used as makeup for the four prophylatic dip tanks and the twelve balloon dip tanks.

Clean molds are coated with latex in these dip tanks. The tanks are cooled with recirculated cooling water. The latex-covered molds are passed through a hot air dryer oven to strenthen the rubber coating. This process is repeated in a second dip tank and dryer train. The latex-covered molds are now cured in air-heated curing ovens. Steam is used to heat both the drying and curing air.

After curing, the dipped goods are sterilized in a 200°F water bath. Steam injection is used to heat the water bath. The overflow from the sterilization bath is negligible since the water loss from the baths by carryover on the molds is approximately equal to the steam makeup.

The dipped items are coated with a talc and stripped from the mold. The products are finally inspected, packaged, and shipped.

Stripped of the cured product, the molds are cleaned and rinsed before being returned to the dip tanks. The cleaner tanks contain a one-percent solution of Oakite Rustripper in water. There is little overflow from the cleaning tank. The rinse tank is raw water but it does pick up talc and cleaning agent from the mold. The rinse overflow waste water is therefore contaminated with surfactants.

Process waste waters arise from the small overflow from the sterilizer tanks, minor discharges from the mold cleaning tank, and from the rinse water overflow. As mentioned earlier, the first two sources are negligible. All process waste waters and the boiler blowdown are directed to holding lagoons. The primary constituents of the process waste waters are the talc and surfactants removed from the molds in the rinsing process.

The waste water treatment facilities in this plant consist of three lagoons, one holding lagoon and two detention lagoons. The holding lagoon is used to contain all washdown and cleaning waters. The detention lagoons treat the rinse water and blowdown for removal of solids. In addition, the latex tanks were rinsed with small quantities of water and wiped clean with rags.

The plant effluent contains: COD, 120 mg/l; BOD, 40 mg/l; suspended solids, 85 mg/l; and oil 4 mg/l. The effluent surfactants level is negligible (less than 1 mg/l).

Plant K

This plant produces compression molded sundries, such as hot water bottles, hygiene syringes and bulbs, and pharmaceutical items. Also produced are latex-dipped goods such as gloves. Daily raw material consumption levels are 28,000 lbs of compounded solid rubber per day and 2,000 lbs of latex per day.

This company compounds the majority of its solid rubber stock in Banbury internal mixers and roller mills. The remaining stock is purchased as a masterbatch and is mixed on mills. In either case, the material is fed to the Banbury or mill and mixed with various compounding agents. After a prescribed mixing time, the materials are sheeted off and air cooled. The sheeted compounded stock can be pelletized or formed into extruded sheets depending on the type of end product.

To form pelletized stock, the sheeted material is fed to a long-barreled extruder. The material is extruded into a continuous cylinder, cooled in a cooling tank, and cut to a prescribed length. The pellets, referred to as slugs, are fed to a shaker screen where they are air cooled and dusted with dry talc. The cooled slugs are stored until needed.

To form extruded sheet stock, the rubber is fed to an extruder-calender. The extruded sheets are passed over cooling drums, dusted with talc, cut to length, and finally sent to storage.

All rubber molded items at this plant are compression molded. The presses are loaded with slugs or sheets depending on the product. Two hydraulic systems provide pressure for the compression presses. The first is a deadweight water system. The second is an oil system. Heat necessary for curing is provided by steam circulated in the cavities of the molding presses. After molding, an operator empties the presses, dips the cured molded items in a cooling tank, and stacks the item on temporary holding skids. The cooling tank water contains a lubricant. The molded items proceed to a die cutter which trims the flash. In some cases, an operator applies a silicone lubricant to aid in the cutting. Finished products, which are formed from two molded pieces, proceed to a second steam-heated press where the pieces are joined together with a rubber cement.

Latex used in the manufacture of dipped goods is brought in by tank cars as a 50 percent emulsion. The stock is blended with other ingredients in a blend tank before being transferred to a dip tank. In the formation of a final product, molds are first dipped in a coagulant. The coagulant is a solution of calcium nitrate dissolved in alcohol. The molds are next dipped in the latex dip tank and then into a leach tank. Finally the latex covered molds are cured in a hot air oven. The leach tank contains 140°F water which is heated by steam injection. The hot air used in the curing oven is heated indirectly with steam. Once cured, the dipped goods are stripped from molds which are recycled to the coagulant tank for the next dipping operation.

Pharmaceutical items produced by this plant must be washed before final packaging and shipping. Washing is carried out in a single 100-gallon washing drum using seven sequential steps. The drum is first rinsed with water to remove contaminants retained from a previous cycle. Next the items are loaded and washed in a chlorinated caustic solution. The next two washes are with detergent. These are followed by a neutralization wash, a hot water rinse wash, and a boiling water final rinse. The items are removed from the drum, dried in a hot air oven, packaged, and eventually shipped.

Process waste waters from this plant arise primarily from the washing of molded and dipped goods. These wastes are characterized by surfactants, BOD, COD, suspended and dissolved solids, and pH spikes. Other process waste waters arise from leakages and spills of oil and water from heavy machinery. Washing of dipping molds also produce a discharge. The molds are cleaned every two to three weeks. A fourth process waste water comprises overflows and cleaning liquids from the dip tanks and other latex handling facilities.

Waste waters are treated with calcium nitrate and "ferro-floc" to coagulate the latex solids, followed by clarification to settle the coagulated solids. The clarified effluent is discharged to a municipal treatment system for further treatment. The principal characteristics of the primary effluent are: COD, 700 mg/l; BOD, 150 mg/l; suspended solids, 800 mg/l; extractable organics, 130 mg/l; and surfactants, 7 mg/l.

Plant L

This plant manufactures latex foam products. Production lines include mattresses, pillows, comfort seating, and slab foam. During normal operating periods the plant is run continuously; however, at the time of this survey a shortage of raw materials had reduced production. Production at the plant during the sampling periods was estimated to consume 200,000 pounds per day of raw materials including the filler. Approximately 135,000 to 150,000 pounds were dry latex solids. The plant is located in a minor urban area with limited plant area available for either production plant expansion or comprehensive waste water treatment facilities.

Production of the latex goods utilizes the Talalay process. Following production of latex at another facility, the latex emulsion is trucked to this plant and pumped into storage tanks. The latex then passes through a freezing-agglomeration step where the pH is lowered with carbon dioxide gas. This causes minor coagulation of the latex to produce larger emulsion solids. The latex is concentrated in an evaporator which pulls off water vapor using a steam jet equipped with a barometric condenser to condense the evaporated water vapor.

After concentrating, additional ingredients (stabilizers, fillers, surfactants, antioxidants, accelerators) are added in the compounding step. The latex mix is then transferred to the steam-heated curing presses using a transfer hose. The high temperature of the press causes specific latex ingredients to decompose, liberating gases which produce the foam effect. In addition, carbon dioxide is injected into the mold to assist the curing process. The final foam product is cooled, rinsed with water, dried, and inspected before shipment.

River water, with a slight chlorine addition, is used in the plant for washings and cooling. It is the only source of nonpotable water in the plant.

The principal process waste waters from this plant arise during process cleanup and product washing. Periodic washdowns occur in the latex storage and freezing-agglomeration areas to clean up latex spills and leaks. These waste waters are laden with latex solids. The final foam products are washed countercurrently to the flow of the wash or rinse water. Progress has been made in reducing the quantities of wash water needed by using a counterflow washing recycle system. An additional source of waste water arises during the evaporation step. Barometric condensers are used to condense vacuum jet discharges and the combined condensates and cooling waters are discharged directly.

Cooling water is once-through and is discharged directly to the river. Boiler blowdown is also discharged without prior treatment. Waste water facilities are employed primarily for the removal of latex solids and zinc ions. High concentrations of latex solids are present in the storage and freezer-agglomeration wash downs. These waste waters are collected in a pit and transferred batchwise to a treatment tank where the pH is adjusted and coagulation chemicals (alum and polyelectrolyte) are added. Latex solids float to the surface and are removed with the tank overflow.

The clarified underflow waste waters are discharged directly to the river. The skimmed latex solids in the overflow are screened and containerized for disposal. The screen filtrate is returned to the chemical treatment tank for continued treatment.

Waste waters from the product washings are treated in a separate system. The wash waters are collected in a pit and are then transferred to a rapid mix tank where lime is added. The resulting zinc hydroxide precipitate is removed in a primary clarifier. The settled solids are dewatered in a vacuum filter and trucked to a landfill. The waste water is discharged directly to the river.

Plans have already been made to upgrade the existing waste treatment facilities. The proposed plant will collect the effluent from the batch latex waste water treatment system and the zinc removal clarifier in an equalization tank. The pH of the waste waters will be adjusted with carbon dioxide to precipitate zinc carbonates. The waste water will then be filtered in a diatomaceous earth filter to remove fine suspended solids and carbonates. The waste waters will then flow to a municipal treatment plant for additional BOD removal.

At present, with the described zinc removal and latex coagulation primary treatments, the effluent quality, including the barometric condenser discharge, is as follows: BOD, 400 mg/l; zinc, 4 mg/l; and suspended solids, 50 mg/l.

Summary of Control and Treatment Technology

General Molded, Extruded, and Fabricated Rubber Subcategories

In-Plant Control

In-plant control measures and practices require proper handling and isolating general spills and leaks of potential contaminants: soapstone and other anti-tack agents, latex compounds, solvents and rubber cements, metal preparation wastes, and wet air-pollution control equipment discharges.

General Spills and Leaks

Most molding, extruding, and rubber fabrication plants (such as hose or footwear production facilities) can generate waste water containing machinery oils and greases as well as suspended solids. If uncontrolled, these waste waters can enter floor drains, thereby polluting the plant effluent. In plants, such as cement dipping facilities where less heavy machinery is used, the oil contamination problem is noticeably reduced.

The exemplary subcategories E, F, and G plants visited shared the following common methods to reduce the type of oil contamination described above: blocking of existing floor drains, removing oil leaks promptly with dry absorbent granules, and in some cases curbing the problem area to contain oil or grease leaks. In cases where a floor drain is required in order to discharge uncontaminated cooling water, for instance, a collar is installed around the floor drain opening to prevent floor drainage from passing into the drain opening.

Plants which have water and oil leakages occurring at the same piece of equipment often use oily-water sumps inside the oil retention areas to collect the highly contaminated water in order that it can be adequately containerized or treated. For cases with relatively voluminous leakages, these collection sumps are equipped with pumps which empty the sumps by pumping the oily water to a location where it can be treated or held or disposal.

Outside storage areas where fuel, maintenance, and process oils are kept are frequent causes of oil pollution in a plant's effluent. The situation is aggravated at these facilities by high run-off rates during storms. The most effective way to prevent contamination of large quantities of storm water is to retain the offending oil, preventing its entering the otherwise clean storm water and, at the same time, roofing the oil contaminated regions to keep the clean storm water from picking up the oil.

In one case observed, compressor oil was transferred from a 55-gallon drum to a smaller container in the close vicinity of an open drain. The floor around the drum and the drain opening was contaminated with oil. Coincident with this observation, oil globules appeared in the final plant effluent. In another plant, discarded drums used to ship process oils were stored in the open. The ground was coated with oil and the stagnant water in a nearby drain had a heavy layer of oil. This oil layer would eventually enter the plant effluent discharge. These two cases point out that good housekeeping, as well as installed control equipment, is vital to the prevention of waste water contamination by oil.

In the plants where good housekeeping and sound control facilities were used the oil loadings in the plant effluent were satisfactory.

Lead-Sheathed Hose Production

In the manufacture of hose via lead-sheath processes, lead-laden waste waters result. The sources of lead are the lead press and cured hose cooling water, and the vulcanizer condensate. In order to properly treat for lead, these streams should be segregated prior to treatment.

Soapstone and Anti-Tack Dip Solutions

The spillage of soapstone and other anti-tack solutions is controlled in exemplary plants in a manner similar to the containment methods used for oils and grease. Floor drains have been blocked or collared to prevent the slurries from entering plant drains and sewers. Spills and drippage are mopped up or are simply allowed to evaporate.

In industries such as cement dipping, few floor drains are required. In the area where the final dipped product is coated with soapstone, the soapstone slurry system is closed and little spillage occurs. A similar approach is feasible for all types of industry in this category.

Latex Compounds

Several types of fabricated product require the use of latex during the manufacture. Latex spills can occur at the storage loading areas, facilities where bulk latex is transferred to drums, and at the processing areas. Where such spills occur, it is common to wash the latex down with water, producing a latex-laden waste water. In addition, drums are frequently rinsed clean with water. These latex waste waters are then chemically coagulated and clarified, usually in a batchwise treatment system.

A more effective way to handle latex is the use of plastic liners in latex drums. When the drum is reused, the old liner is discarded. In this manner, waste waters from drum cleaning are not generated. Latex spills around storage and transfer facilities are coagulated with alum *in situ* and scraped from the ground. In the processing areas where latex is used, floor drains have been blocked. This approach is used by a footwear plant which, although it was not visited, was surveyed on this specific subject.

Solvents and Rubber Cements

Many plants use rubber cements as adhesives. In addition, the cement dipping industry handles large quantities of cements and solvents. In most of the cases observed, these organic liquids are mixed and stored in areas without floor drains. This is by far the most positive method to control solvent or cement spills and leaks. Incidentally, solvents should be kept out of plant drains for reasons of safety as well as effluent quality, since they have high flammability and explosiveness.

Metal Preparation

The methods used to prepare and recycle metal components for rubber bonding were essentially dry. Degreasing liquids were used in closed systems and discarded when saturated with grease.

It is believed that some plants use acid pickling to prepare metal components. The pickling and metal rinse waste will exhibit low pH and high heavy metal concentrations. It is understood that precipitation of the metals and pH adjustment is carried out to effectively treat such wastes before combination with other plant waste waters. Alternatively, the pickling wastes are containerized and hauled from the plant. Plants employing extensive metal preparation should control waste waters from such operations according to metal finishing regulations.

Air Pollution Control Equipment

Wet scrubbing devices are used in the rubber compounding and product buffing areas. Although wet scrubbing devices are used to trap rubber-buffing and metal sand-blasting fines, dry air-pollution control devices are also applicable and are used in many plants within the industry. In some plants where waste water discharge requirements are stringent and the use of bag collector devices is also inappropriate, the waste waters from wet scrubbing devices are settled and filtered before discharge, or a municipal treatment system is used to accept the waste waters. Wet scrubbers exist within some plants that greatly add to the process waste water usage and loadings. Additional limitations which take into consideration TSS from wet scrubbers have been applied to BPCTCA and BATEA. BPCTCA is based upon current practice, while BATEA is dependent upon recycle and treatment of concentrated wet scrubber waste waters.

End-of-Pipe Treatment

In general, only minor end-of-pipe treatment is used by the industries covered by this industry segment. This is due largely to the fact that process waste water contamination is limited to essentially two parameters: oil and grease, and suspended solids. In addition, good effluent quality can be achieved most economically by employing good housekeeping practices with well-designed in-plant control measures.

Of the Subcategories E, F, and G plants visited, only two had primary treatment systems and none used secondary treatment. Furthermore, only one of these plants used the local municipal sewage treatment system to provide the equivalent of secondary treatment. These facts indicate that the magnitude of waste water pollution is not appreciable or the problem can be effectively controlled by sound prevention and in-plant control measures.

One plant uses gravity separation to remove oil from the combined plant effluent. This combined effluent includes utility and storm waters as well as process waste water. In-plant control measures are employed as the primary method of oil reduction and the oil separators are designed as a backup system. In addition the plant's boiler blowdown, autoclave condensate, and compressor condensates pass through a holding pond to separate solids and oils from these waste water types before discharge. The holding pond also allows these waste waters to cool before they are discharged.

The other plant (manufacturing footwear) which does employ primary treatment uses appreciable quantities of latex adhesives. The handling of these materials produces latex-laden waste waters which are chemically coagulated and allowed to separate in a batchwise manner. It is debatable whether this treatment method for latex waste waters is the most appropriate or whether the latex waste water can be eliminated completely in the use of different handling and dry cleanup techniques. This plant utilizes oil collection-separation sumps to trap oil leaks produced at the mills and other heavy machinery.

The quality of the effluent from the one plant which discharges to a municipal treatment system is satisfactory for the municipal system without primary treatment or pretreatment. This quality of effluent can be achieved when correct waste water control and housekeeping procedures are followed.

Wet Digestion Reclaimed Rubber Subcategory

In-Plant Control

The wet digestion reclaiming process is declining even more rapidly than the reclaiming industry as a whole. There are only about three wet digester reclaiming plants remaining, and the incentives for process modifications, particularly those modifications leading to lower waste water flows and loadings, are few. However, the control measures used by the wet digestion industry include containment of pollutants by the recycle and reuse of waste water streams.

General Spills and Leaks

Oil and grease spills and leaks occur around the heavy cracking and grinding machinery used to prepare the scrap rubber for the digestion process as well as the milling areas for the final reclaim rubber product. In addition, rubber fines are generated which can enter into plant drains. Outside storage areas used to store fuel, machinery, and process oils produce oil-laden waste waters if spillage and storm water are allowed to contact each other.

The accepted method of controlling these types of contamination is similar to that employed by general molded, extruded, and fabricated rubber plants, namely, containment of the leaks and spills with separate handling and disposal procedures and at the same time reduction in the volume of water. For example, storm and cooling waters that are uncontaminated are not allowed to come in contact with the polluting spills and leaks. Good housekeeping is an important element in the control of the contamination of cooling water and storm water.

Digestion Liquor and Oil Recycle

The dewatering liquor is the major waste water stream by wet digestion reclaim plants. The reclaim plant visited (Plant I) uses a recycle system which returns the dewatering liquor and reclaimed process oils to the digestion step. This system is illustrated in Figure 9 in the section on Plant I.

The dewatering liquor is collected at the rubber dewatering screen and sent to a storage tank from where it is returned to the digester. The liquor storage tank requires constant agitation to suspend solids, particularly rubber particles, thereby preventing a dense and tacky buildup in the tank.

Vapor condensates and cooling waters from the blowdown tank and dryer are sent to a decanting tank where oils and other organics are decanted.

The decanted oils are sent to an oil storage tank where the residual water content is drawn off the bottom, and the top layer (oils and organics) is returned to the digester for reuse. The bottom water layer is returned to the first decanter.

The bottom water layer from the first decanter is pumped to the dewatering liquor storage tank where it mixes with the digester liquor before being returned to the digestion process. Part of the bottom water layer from the first decanter is slip-streamed to the sewer to blow down accumulating compounds. It is this stream that is finally discharged in the plant's effluent. The flow and loadings of this discharge are lower than the equivalent stream without the recycle and reclaim system. This comparison is shown in Table 15.

The oils and dewatering liquor that are returned to the digestion step of the reclaim process require makeup but the chemical usage is less than the equivalent process consumption without recycle and reclaim.

Vapor Condensates

In theory, it should be possible to use vacuum pumps to exhaust the blowdown tank and dryers. However, the advantages of steam ejectors over vacuum pumps are their reliability, trouble-free operation and overall economy. The use of vacuum pumps would reduce the condenser cooling load and the final volume of condensate.

The above modification has more merit if indirect cooling condensers are used in place of barometric condensers. The volume of condensate with a vacuum pump and indirect condenser would be considerably lower than with a steam ejector and barometric condenser.

Scrap Defibering

The method by which the scrap rubber is defibered has a considerable effect on the loading of the digester dewatering liquor. If scrap containing fiber is fed to the digester together with the necessary defibering chemicals, the dewatering liquor will contain the solubilized fiber residue. In addition, the defibering chemicals, which are discharged along with the dewatering liquor, can contain contaminants, possibly heavy metals. Furthermore, chemical defibering precludes the use of the recycle and reclaim system as described above.

As an alternative to chemical defibering, defibering by mechanical or physical techniques can be used. In brief, the waste water benefits of this method are: fiber-free dewatering liquor, no chemical defibering agents in the liquor, and reduced dewatering liquor discharge due to liquor recycle. In cases where liquor recycle can be utilized, the usage of process oils and digestion chemicals is also significantly reduced.

Alternative Reclaim Process

The conversion of a wet digestion reclaiming plant to any of the three dry reclaiming processes (pan, mechanical, or dry digestion), in order to improve the quality of the plant's effluent would constitute considerably more than an in-plant control measure. However, it is appropriate to note at this point that the three dry processes give significantly lower waste water flows and loadings than the wet digester process. The wet digester process can more readily be converted to the dry digester process than to either the pan (heater) or mechanical processes.

End-of-Pipe Treatment

Plant I employs little end-of-pipe treatment; and a decanter for oil and grease separation. This is the only wet digester reclaim process known to discharge directly to a stream or river. All other wet digester plants discharge to municipalities which are reportedly able to treat this type of waste water adequately. In view of the fact that little end-of-pipe treatability data exist, and since the few wet digester reclaim plants still operating will most probably continue to use local municipal treatment systems indefinitely, it is difficult to comment meaningfully on the merits of potential, but unproven, end-of-pipe treatments.

However, it can be stated positively that the most common and apparently most appropriate end-of-pipe treatment for wet digestion process waste water is afforded by publicly owned treatment works.

Pan (Heater), Mechanical, and Dry Digestion Reclaimed Rubber Subcategory

In-Plant Control

In comparison to the wet digester process, the waste waters from the dry reclaim process (pan, mechanical, and dry digestion) have lower flow and are less contaminated. This is due primarily to the absence of the dewatering liquor. The scope for in-plant waste water controls is thereby reduced and is limited to the containment of spills and leaks, and the effective condensation and decanting of vaporized process oils and organics.

General Spills and Leaks

The flows, characteristics, and applicable control methods of the spills and leaks in the dry reclaiming industry are similar to those found in Subcategories E, F, and G.

The spills originate at heavy equipment, and material handling and storage areas. The contaminants are characterized by oil and suspended solids and are prevalent in the scrap cracking, scrap grinding, product milling, and oil storage areas.

Successful control techniques include good housekeeping, curbing and drain blockage to contain the spills, and isolation modifications which restrict the spread of the polluting material and prevent contact with uncontaminated waters.

Vapor Condensates

The exhaust vapors from the devulcanizer ovens require condensing to minimize air pollution. This exhaustion-condensation is normally carried out using a steam-ejector barometric-condenser system. Although this type of system is reliable and economic, the volume of condensate and cooling water is greater than the volume of condensate produced by a vacuum pump and noncontact condenser.

Plant I, which operated both wet digester and pan reclaim processes, decanted the barometric condenser cooling waters plus condensates from the pan process, recycling both the reclaimed oil and water layers to the wet digester process. It is believed that the reclaimed oil cannot be recycled to the devulcanization step of the pan process because the quality of the feed process oil is more critical in the pan process. Therefore, for plants with only the pan process, the oily vapor condensate must be disposed of as a waste. However, the basic technologies used at Plant I to recycle the components of the vapor condensates can be applied at plants operating only the pan process to control the flow and loadings of vapor condensate waste waters. The barometric-condenser cooling water and condensibles mixture can be decanted. The top oil layer can be containerized for disposal and the bottom water layer can be cooled in a noncontact heat exchanger before it is recycled to the barometric condenser for cooling water. A portion of the water layer should be slip-streamed to the plant sewer to blowdown accumulating organics.

End-of-Pipe Treatment

The dry reclaiming plants throughout the industry do not generally use end-of-pipe treatment for their waste waters. A large proportion of the plants in existence discharge their waste waters to municipal treatment plants. No treatability data exist for the biological treatment of pan, mechanical, or dry digester processes. In fact the BOD is so low (20 mg/l typically) that biological treatment is inappropriate.

It is possible that separators or holding ponds are used by some plants to act as a catch-all for all plant waste waters in order to trap oils and suspended solids that have bypassed or escaped in-plant controls previously described. It is belived that such a catch-all is not necessary if adequate in-plant control and good housekeeping are practiced.

Latex-Based Products Subcategories

In-Plant Control

Since Subcategories J and K represents the latex-based industries, the in-plant controls employed by this industry are designed primarily to control, handle, and treat latex-laden waste waters. In addition, some individual streams such as foam rinse water or dip form-cleaning water require special control and treatment measures.

General Latex Spills and Leaks

Both the latex-dipped goods (Subcategory J) and the latex foam (Subcategory K) industries generate latex-laden waste waters. The quantity of latex consumed by the latex foam plant visited is considerably higher than the latex usage at the average latex-dipped goods production facility; generally, the latex shipping, storage, and handling procedures are different.

In a dipped goods facility the latex is generally shipped in by tank car or tank truck and transferred to a storage tank. After compounding, the latex mixture is usually taken into the dipping areas in 55-gallon drums. The major spillages and washdowns occur at the storage unloading area and in the latex compounding building. In addition, the transfer drums require cleaning between latex mixes and this produces a latex-laden waste water. In the dipped goods plants that were visited, no treatment of the latex waste waters is carried out before they mix with the total plant effluent.

In the latex foam plant, the latex-laden waste waters are generated at the latex concentration, intermediate storage, and curing press areas. The waste waters from these operations are collected in a separate drain system and treated by chemical coagulation and clarification. As part of this overall system, the areas where the latex spills and leakages occur are designed to restrict the spread and further contamination by the latex wastes. The coagulation and clarification system for latex waste water consists of a collection pit which feeds a batch treatment tank (10,000 gallons). The waste water pH is adjusted using sulfuric acid and caustic soda and the solids are coagulated using alum. The coagulated solids float to the water surface where they are skimmed off and screened in a strainer. The screened water is returned to the treatment tank and the solids are landfilled. The clarified waste water overflow is discharged to the plant drain.

Foam Rinse Waters

After curing, latex foam requires rinsing to remove excess compounding and curing agents entrained in the foam matrix. The resulting rinse waters pick up soluble zinc compounds and the zinc concentration in these wastes is high (typically 700 mg/l). A significant reduction in the volume of this rinse water was achieved at Plant L by employing a countercurrent rinsing process. This is represented schematically in Figure 8 in Section III. The zinc-laden rinse water is then treated for zinc removal in a continuous chemical precipitation and clarification system. Precipitation is accomplished by adjusting the pH to approximately 12 by the addition of lime, and by the addition of a polyelectrolyte. The operation is carried out in a rapid mix tank. The mixture then passes to a flocculation tank where the precipitation and flocculation processes are completed. The tank has mild agitation sufficient to gently mix the waste water components but not sufficiently powerful to break or destroy the desired floc. The flocculation water then enters the clarifier where the zinc precipitate is settled. The clarified effluent (zinc concentration about 10 mg/l) is then discharged to combine with the total plant effluent. The zinc sludge is drawn off from the bottom of the clarifier and filtered on a vacuum filter. The filtrate is recycled to the mix tank. The filtered sludge is sent to landfill. The filtering system at Plant L preheats the zinc-lime sludge to enhance the filterability of the sludge. Studies are to be made to reclaim the zinc and recycle it to the latex compounding stage. The feasibility of this approach has yet to be determined.

Form Cleaning Wastes

In most latex dipping facilities, the dip forms require cleaning. In some case this is necessary on each dip cycle prior to the first dip tank; in other plants only periodic cleaning is required.

Frequent cleaning operations can be performed in a tank of water containing detergent or some other type of cleaning liquid. The form can be simply dipped into the cleaning water and gently scrubbed in the tank with mechanized scrubbing equipment. After the cleaning step, the forms are rinsed before the latex dipping operation. The rinse water is allowed to overflow from the rinse tank and contains detergent or cleaning agent and exhibits a BOD load. Plants limit the volume and loading of the rinse water overflow more by reliance on mechanical scrubbing than on the activity of the detergent agent. In addition, countercurrent rinsing is sometimes employed in which the final rinse water overflows to the first rinse tank where a higher concentration of detergent can be tolerated. The volume of rinse water discharged is thereby reduced.

In some dipping plants, the forms are cleaned only periodically, usually when they become fouled with rubber. One method to clean this type of stubborn rubber deposit is to dissolve it in chromic acid and rinse the acid from the form. The form rinse water collects the chromic acid and is characterized by low pH and hexavalent chromium. A satisfactory method of treating this type of waste water, as employed by the industry, is the batch precipitation of the chromium. To do this, the chromium has to be reduced to the trivalent state. The pH of the rinse water is lowered to 2 with sulfuric acid and the hexavalent chromium reduced to trivalent chromium using ferrous sulfate. The trivalent chromium is then precipitated using lime at a pH of approximately 9 and allowed to settle. The settled lime sludge is then dried on a sludge drying bed.

End-of-Pipe Treatment

The latex dipping plant visited coagulated the latex solids chemically and settled them from the total plant effluent. The clarified primary effluent is then discharged to the local municipal system. This effluent quality is suitable for treatment in the municipal treatment works.

The other latex-dipped goods plant passes the bulk of its waste water through a two-pond settling lagoon system prior to final discharge to a receiving stream.

Some latex dipping plants use aerated lagoon and settling pond treatment systems to treat the waste waters. These systems perform well. Few plants use activated sludge treatment. It is considered that the waste water loadings, particularly BOD, are too low to produce an adequate biomass. Therefore, aerated lagoon and settling pond systems are more applicable.

Many latex dipping plants use the local municipal treatment plant to treat the primary effluent after chemical coagulation and clarification of the latex solids. This type of treatment is very suitable and is possibly the most attractive economically for most plants that are adjacent to a municipality.

The latex foam plant that was visited is proposing, based on a pilot study, to treat the total effluent further before discharging it to a municipal system. Both the clarified latex wastes and rinse waste waters after zinc removal will be combined and passed through a 25,000 gallon equalization tank. The equalized flow will be treated with carbon dioxide to lower the pH to approximately 8 units (the original pH will be higher than 8 because the clarified rinse water, after zinc precipitation and removal, has a pH value of 12). At pH 8 some soluble species, particularly zinc, will be converted to insoluble carbonates. The waste water will be filtered in a diatomaceous earth filter before it is discharged. The filter will generally polish the effluent removing the fine carbonate precipitate. The carbonate precipitate will include a portion of the residual zinc that has been carbonated. It is anticipated the filtered effluent will eventually be discharged to the local municipal system. This will not occur until the city plant is expanded, in a few years' time.

SECTION VIII

COST, ENERGY, AND NONWATER QUALITY ASPECTS

General Molded, Extruded, and Fabricated Rubber Subcategories

Two fundamental approaches can be applied for the control and treatment of process waste waters produced by Subcategories E, F, and G production facilities.

The first approach is to combine process and nonprocess waste waters and to treat the entire plant effluent. Where land is available, onsite end-of-pipe treatment is practiced at some of the plants. At other plants, the total effluent is discharged to the local municipal treatment facilities. In either case, the reasons for treating or discharging a combined effluent are as follows:

1. In general molded, extruded, and fabricated rubber plants, in-plant sewers for process and nonprocess waste waters are usually combined, thus making combined treatment more attractive.
2. Process flows are usually small relative to nonprocess flows.
3. The treatment of nonprocess waste waters has received the bulk of industry's attention. For example, high suspended solid loadings contained in blowdown and water treatment wastes are a major pollutant in the combined plant effluent from rubber processing facilities.

However, end-of-pipe treatment systems also have several disadvantages:

1. The combined effluent treatment system usually requires oil removal equipment and/or a holding pond or lagoon system to separate the oil. Lagooning of the wastes generally requires considerable land area.
2. Because of dilution, the effectiveness of treatment for oil and solids removal from process waste water is reduced. In several of the systems observed, oil passed through the system with low removal efficiency, because its concentration was below the capabilities of the treatment system employed. This phenomenom occurs even though the oil loading is significant, because of the dilution afforded by nonprocess waste waters.

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The second approach employed is control and treatment of an isolated and undiluted process waste water. This approach has been followed in plants having partially or wholly-segregated process and nonprocess sewers. The

key to this treatment approach is the reduction, containment, and isolation of the contaminated process waste waters prior to treatment. The principal advantages for this treatment approach over the end-of-pipe treatment of the combined plant effluent are:

1. Higher pollutant (primarily oil and suspended solids) removal rates.

2. Smaller treatment units and land area requirements.

The primary disadvantage of a segregated system approach is that separate process and nonprocess sewers are required. This will necessitate in-plant modifications which, if not carefully planned, can lead to significant production disruptions.

Evaluation of these alternatives indicated that control and treatment of segregated process waste waters is the most effective and generally applicable treatment approach for this industry. End-of-pipe treatment of combined waste waters is not feasible for pollution control because of the ineffectiveness of such systems in removal of diluted process waste water contaminants, and the larger land requirements.

Incidentally, a viable alternative treatment for waste waters (process as well as nonprocess) generated by this industry is discharge to the local publicly owned treatment works. Such discharge is contingent on adequate pretreatment.

All costs presented are related to the control, followed by treatment, of segregated process waste water streams. It can be further stated that this type of treatment approach is considered to be the best practicable control and treatment technology currently available to the industry.

With proper in-plant control, the process streams consist of readily separable lubricating and extender oils, and settleable solids. Volumetric flow rates for process waste waters are small. Therefore, the initial treatment applicable from a proven operation basis is an API-type gravity separator. The performance and efficiency of a gravity separator can be improved by addition of an filter coalescer. The corrugated plate interceptor (CPI) type of device is also applicable generally to this industry. The choice between the API or CPI separators will depend on land availability and the type of waste water control, handling, and treatment equipment already presert at the plant. Since the cost and treatment effectiveness of the API and

CPI type separators are comparable, the effluent limitations treatment and costs presented are based on the use of API type separators.

Effluent quality data for Subcategories E, F, and G are presented in Tables 20, 21, and 22. The treatment basis includes isolation of wastes with curbing, protection of uncontaminated waste streams (such as cooling water and storm run-off), blocking unnecessary floor drains, the covering of oil-handling areas to prevent contamination of storm run-off, and separation of settleable solids and oily material from the waste water.

A more detailed description of the recommended facilities is presented in the Subcategories E, F, and G portion of Section IX, and a flow diagram of a typical system, used as a basis for costing, is presented in Figure 10.

Treatment Cost Data

Data collected during the plant operations and waste water analysis visits plus data from Corps of Engineers permit applications were utilized to obtain typical plant size and process waste water flows and raw loadings. The analysis approach and findings are described in Section V.

As stated previously, Subcategories E, F, and G plant effluents can be divided into two groups: process and nonprocess waste waters. The process waste waters consist of mill and curing areas, oily waters, anti-tack and latex spills and leaks, area washdown waters, wet scrubber discharges, and contaminated storm waters from material and fuel oil storage and handling areas. The nonprocess waste waters, which are not the subject of this document, include sanitary, noncontaminated storm water, and utility waste waters, such as once through noncontact cooling water, boiler blowdown, cooling tower blowdown, and water treatment wastes. In addition noncontaminated process-associated waste waters such as extrusion contact cooling waters, and hydraulic (hose manufacture) and conductivity (cement dipped electrical gloves) test waters can be included with nonprocess waste waters, for the scope of this document, since they should not require any treatment at all prior to discharge. These waters need not be mixed with other process waters prior to treatment, and therefore should not affect the treatability of the waste waters.

The aforementioned data sources indicated that the following flow adequately described the process waste waters generated by Subcategories E, F, and G plants:

	Typical Plant Size kg/day (lb/day) raw materials	Product Size Range kg/day (lb/day) raw materials	Process Waste Water Flow L/day (gpd)
Small:	900 (2,000)	less than 3,720 (8,200)	14,700 (3,900)
Medium:	7,700 (17,000)	3,720-10,430 (8,200-23,000)	75,800 (20,000)
Large:	15,400 (34,000)	greater than 10,430 (23,000)	95,900 (25,300)

	Treatment or Control Technology[1] A	Treatment or Control Technology[1] B
Investment[2]	$79,000	$84,000
Annual Costs		
Capital Costs	$ 7,900	$ 8,400
Depreciation	15,800	16,800
Operating and Maintenance Costs (excluding energy and power costs)	11,400	12,900
Energy and Power Costs	600	600
Total Annual Costs[2]	$35,700	$38,700

Parameters kg/kkg (lb/1000 lb) raw materials	Raw Waste Loads	Effluent Quality A	Effluent Quality B
Suspended Solids	3.500	0.640	< 0.640
Oil and Grease	1.000	0.480	0.160

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[1] Technology A is isolation of process waste waters followed by API gravity separation. Technology B is Technology A followed by a filter coalescer.

[2] August 1973 dollars.

Table 20: Estimated Waste Water Treatment Costs at Different Degrees of Treatment for a Subcategory E Plant

	Treatment or Control Technology[1]	
	A	B
Investment[2]	$163,000	$171,000
Annual Costs		
Capital Costs	$ 16,300	$ 17,100
Depreciation	32,600	34,200
Operating and Maintenance Costs (excluding energy and power costs)	18,200	23,200
Energy and Power Costs	800	800
Total Annual Costs[2]	$ 67,900	$ 75,300

Parameters kg/kkg (lb/1000 lb) raw materials	Raw Waste Loads	Effluent Quality	
		A	B
Suspended Solids	1.220	0.400	< 0.400
Oil and Grease	0.600	0.300	0.100

[1] Technology A is isolation of process waste waters followed by API gravity separation
Technology B is Technology A followed by a filter coalescer

[2] August 1973 dollars.

Table 21: Estimated Waste Water Treatment Costs at Different Degrees of Treatment for a Subcategory F Plant

	Treatment or Control Technology[1]	
	A	B
Investment[2]	$212,000	$223,000
Annual Costs		
Capital Costs	21,200	22,300
Depreciation	42,400	44,600
Operating and Maintenance Costs (excluding energy and power costs)	20,800	27,800
Energy and Power Costs	1,200	1,200
Total Annual Costs[2]	$ 85,600	$ 95,900

Parameters kg/kkg (lb/1000 lb) raw materials	Raw Waste Loads	Effluent Quality	
		A	B
Suspended Solids	0.900	0.250	< 0.250
Oil and Grease	0.380	0.189	0.063

[1] Technology A is isolation of process waste waters followed by API gravity separation
Technology B is Technology A followed by a filter coalescer

[2] August 1973 dollars.

Table 22: Estimated Waste Water Treatment Costs at Different Degrees of Treatment for a Subcategory G Plant

	Treatment or Control Technology
	A
Investment²	90,000
Annual Costs	
Capital Costs	7,200
Depreciation	4,400
Operating and Maintenance Costs (excluding energy and power costs)	11,500
Energy and Power Costs	2,300
Total Annual Costs²	25,700

Parameters kg/kkg (lb/1000 lb) raw materials	Raw Waste Loads	Effluent Quality
		A
Lead	0.030	0.0007

[1] Technology A is diatomaceous earth filtration.
[2] August 1973 dollars.

Table 23: Estimated Waste Water Treatment Costs for Lead Treatment for Subcategories, E, F, and G.

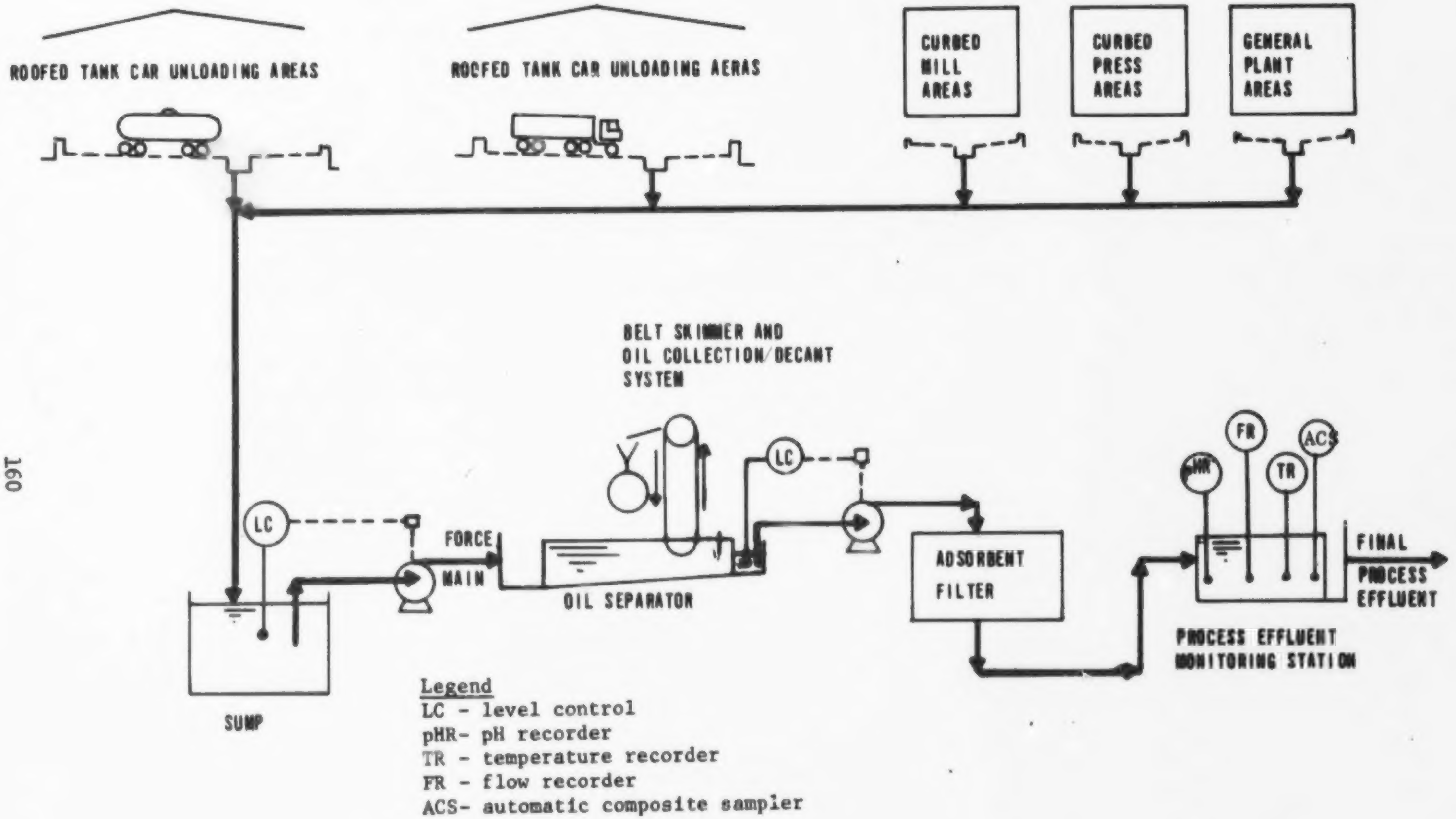
ROOFED TANK CAR UNLOADING AREAS
ROOFED TANK CAR UNLOADING AERAS
CURBED MILL AREAS
CURBED PRESS AREAS
GENERAL PLANT AREAS
BELT SKIMMER AND OIL COLLECTION/DECANT SYSTEM
LC
FORCE MAIN
OIL SEPARATOR
LC
ADSORBENT FILTER
pHR
FR
TR
ACS
FINAL PROCESS EFFLUENT
PROCESS EFFLUENT MONITORING STATION
SUMP
Legend
LC - level control
pHR- pH recorder
TR - temperature recorder
FR - flow recorder
ACS- automatic composite sampler

FIGURE 10: HYPOTHETICAL WASTE WATER SEGREGATION AND TREATMENT FACILITY FOR SUBCATEGORIES E, F, G, AND I PLANTS

From these typical flow values for Subcategories E, F, and G facilities, treatment cost data were generated and are presented in Tables 20, 21, 22, and 23, as well as the estimated raw oil and suspended solids loadings of the process wastes associated with the three typical plant sizes. The cited costs for all sizes of Subcategories E, F, and G production facilities are based on the cases where no treatment facilities that could be modified yet exist, and no reduction or isolation measures for the containment of contaminated process waste waters have been taken. These cases were chosen since the design considerations (i.e., the influent raw waste loads) were selected to represent the expected raw waste load within each subcategory. This results in the generation of cost data which should be conservative when applied to most of the plants in this industry. Relatively conservative cost figures are preferred for this type of general economic analysis.

The total annual costs for the BPCTCA and BATEA control and treatment technologies can be expressed as incremental costs per unit of production or raw material consumption. Study of the cost data for the three typical plant sizes indicates that the BPCTCA and BATEA treatment costs per unit of raw material consumption are approximately:

Typical Plant Size kg/day (lb/day) raw material		Annual Treatment Cost August 1973 dollars	Incremental Treatment Cost cents/kg (¢/lb) raw material
Small:	900 (2,000)	38,700	14.3 (6.5)
Medium:	7,700 (17,000)	75,300	3.3 (1.5)
Large:	15,400 (34,000)	95,900	2.1 (0.9)

The above incremental costs are based on a 300 working-day year; that is, 50 working weeks per year and six (6) operating days each week.

It can be seen that the incremental treatment costs to the small- and medium-sized plants are extremely high. Compared to the cost of rubber raw material (approximately 30 to 50 cents per pound), the treatment costs appear to be a burden on the small plants in particular. This analysis underlines clearly the cost benefits to be derived by complete elimination of process waste waters by good housekeeping and closed spill and leak containment facilities or by utilization of the local municipal treatment system. In addition, the elimination of direct discharge of process waters to navigable waters will eliminate the expense of waste water analyses and permit reporting.

The capital costs were generated on a unit process basis, with the following "percent add on" figures applied to the total unit process costs in order to develop the total installed capital cost requirements:

Item	Percent of Unit Process Capital Costs	
	Small Plants	Medium and Large Plants
Electrical	15	12
Piping	20	15
Instrumentation	15	8
Site Work	10	5
Engineering Design and Construction Supervision Fees	10	10
Construction Contingency	15	15

Some of the "percent add on" costs are higher in the case of the small, Subcategories E, F, and G plants than the equivalent values for the medium and large plants since these costs are disproportionately higher (in terms of a percentage of the unit process cost) in the case of small plants.

Since land costs vary appreciably between plant locations, it was decided to exclude land cost from the total capital cost estimates. Land costs must be added on an individual case basis.

Annual costs were computed using the following cost basis:

Item	Cost Allocation
Capitalization	10 percent of investment
Depreciation	5-year straight line with zero salvage value
Operations and Maintenance	Includes labor and supervision, chemicals, sludge hauling and disposals, insurance and taxes (computed at 1.6 percent of the total capital costs), and maintenance (3.2 percent of the total capital cost)
Power	Based on $0.015 kw-hr for electrical power

The short-term capitalization and depreciation write-off period is what is currently acceptable under current Internal Revenue Service Regulations pertaining to pollution control equipment. Economic analysis indicates other allowable methods of depreciation write-off are more advantageous. The annual costs presented in this document have therefore been overstated. The document, Economic Analysis of Effluent Guidelines The Rubber Processing Industry (Phase II), contains revised annual costs, reflecting optimum depreciation write-off.

All costs, capital and operating, were computed in terms of August 1973 dollars, which correspond to an Engineering News Record Index (ENR) value of 1920.

Energy Requirements

Energy input is related solely to the need for electric pumps to pump process waste waters from the plant areas through the treatment system. The additional power requirements for control and treatment systems are small and deemed minor in comparison with the power usages of rubber processing machinery and equipment common to the industry. The power requirements for waste water control and treatment are estimated to be:

Typical Plant Size kg/day (lb/day) raw material		Treatment Equipment Power Requirements horsepower
Small:	900 (2,000)	6
Medium:	7,700 (17,000)	8
Large:	15,400 (34,000)	12

Electrical costs, as presented in Tables 20, 21, and 22, are estimated at $0.015 per kilowatt hour which is equivalent to $98 per horsepower-year.

Nonwater Quality Aspects

The primary nonwater quality aspect deriving from use of a separator is the need for disposal of oil and solids. Additional solid waste results from the use of a nonregenerative type filter coalescer.

Disposal of process solid waste, such as waste rubber or rejected products, is a problem confronting the industry as a whole. Additional solid waste results from the drumming of waste liquid, such as latex solutions, for off-site disposal. Many manufacturing plants, particularly in the northern states, are finding it difficult to locate and arrange for service at satisfactory landfill sites. Fortunately, the additional solid waste generated by the proposed treatment technology is very small relative to the normal solid waste generated by the production facility and is considered insignificant.

Land requirements for the treatment system are small; nevertheless, certain facilities located in highly congested urban areas will find it difficult to allocate space for even this minimal treatment facility. These plants may be forced to turn to other treatment methods or to approach zero discharge to navigable waters by advanced housekeeping and control techniques.

For those waste materials considered to be non-hazardous where land disposal is the choice for disposal, practices similar to proper sanitary landfill technology may be followed. The principles set forth in the EPA's Land Disposal of Solid Wastes Guidelines (CFR Title 40, Chapter 1; Part 241) may be used as guidance for acceptable land disposal techniques.

For those waste materials considered to be hazardous, disposal will require special precautions. In order to ensure long-term protection of public health and the environment, special preparation and pretreatment may be required prior to disposal. If land disposal is to be practiced, these sites must not allow movement of pollutants such as fluoride and radium-226 to either ground or surface water. Sites should be selected that have natural soil and geological conditions to prevent such contamination or, if such conditions do not exist, artificial means (e.g., liners) must be provided to ensure long-term protection of the environment from hazardous materials. Where appropriate, the location of solid hazardous materials disposal sites should be permanently recorded in the appropriate office of the legal jurisdiction in which the site is located.

Lead-Sheathed Hose Plants

For plants producing hose via lead-sheath processes, control of lead is required. Treatment for lead should begin with the segregation of lead cooling waters and vulcanizer condensate. Treatment for lead can be accomplished by pre-coat filtration which industry has stated would cost $90,000 for a 28,750 lb/day plant. Other control technologies appear to be also reasonable. Recycle of lead-laden waters using a cooling tower, and treatment of a concentrated blowdown stream may be more advantageous. This would reduce water costs and result in a smaller more concentrated stream to treat.

Wet Digestion Reclaimed Rubber Subcategory

The rubber reclaiming industry is presently undergoing a decline in both the number of operating plants and the quantity of reclaimed rubber produced. The wet digester reclaiming process has borne the brunt of this decline, and it must be assumed that the financial resources of wet digester reclaim plants and their ability to shoulder further operating costs such as waste water treatment costs are limited. In view of this and since all of the existing wet digester plants discharge their waste waters directly or are connected to the local publicly owned sewage treatment works, it is not possible to propose an end-of-pipe treatment technology which has been proven to be operable and successful while in service, as well as economically practicable.

With this in mind, attention has been duly given to in-plant modifications to the wet digestion process which have been implemented and proven successful in at least one plant. Such modifications, while reducing waste water pollution and end-of-pipe treatment needs, also have the potential to reduce raw material wastage and consumption. However, based on the preliminary findings of this guideline study, it cannot be said that the yearly reductions in process operating costs afforded by the in-plant modifications will offset the annual operating and maintenance costs directly attributable to the modifications. Such benefits can be assessed only by personnel intimately familiar with the wet digestion process and the economics of is operation.

The principal waste water streams in a wet digestion relaim plant are the dewatering liquor and the vapor condensates from the blowdown tank and dryer. The type of treatment proposed for Subcategories E, F, G, and I, namely, the isolation of wastes loaded with oil and suspended solids followed by oil and solids removal, is not appropriate as BPCTCA control and treatment for Subcategory H since the costs benefits are not favorable. This argument is particularly valid when the minimal benefits to be achieved by this type of alterations are compared to the greater pollution reduction that can be attained by the application of the recommended recycle. It should be remembered at this point that the wet digester process is only marginally profitable and, at present, cannot bear large waste water treatment costs. In addition, most wet digester plants discharge to municipal systems and will be subject to pretreatment guidelines.

A fundamental change that can be made to the wet digestion reclaiming process is the conversion from chemical defibering to mechanical defibering. With chemical defibering, defibering chemicals are added to the digestion mix. The fibers are solubilized in the digestion step and leave the process system in the dewatering liquor which is discharged. The defibering chemicals, which can be of a toxic nature, are an additional constituent of the dewatering liquor. In the mechanical defibering variation, the scrap rubber is finely ground prior to digestion. The freed fiber is then elutriated from the rubber scrap on air separation tables.

With mechanical defibering the dewatering liquor is free of high levels of solubilized fiber as well as the chemical defibering agents themselves. Costs incurred by a conversion from chemical to mechanical defibering have not been fully developed for this document since the required technology for the conversion is specific to the reclaiming industry and outside the scope and technology boundaries of the guideline study. However, the costs associated with a recent conversion from chemical defibering to mechanical fiber separation illustrate the order of magnitude of the capital costs. The conversion of a 130,000-pound per day wet digestion plant from chemical defibering to mechanical fiber separation cost $611,000 in 1969-70. This modification included $31,000 for fiber lint air emission controls.

A major reduction in the volume and loadings of the process waste waters can be achieved by adding a recovery and recycle system to the wet digestion process. In essence the dewatered liquor can be recycled back to the digestion step with a blowdown of accumulating contaminants and a make-up of the digestion liquor. At the same time the vapor condensates from the blowdown tank and dryer are decanted to recover the insoluble oils and organics. The oils and organics are recycled to the digestion liquor makeup operation, and the water underflow from the decantation is returned with the dewatered liquor. As a result of this recycle system, the volume and loadings of the dewatering liquor are considerably reduced. It should also be noted that mechanical, opposed to chemical, defibering is required in order for this system to be feasible. The dewatering digester liquor must be fiber-free in order that part of it can be recycled.

The quality of the effluent achieved by this recycle system is presented in Table 24 together with the associated control and treatment costs. The costs do not include the costs incurred by the necessary conversion from chemical to mechanical defibering.

A detailed description of the suggested recycle and reclaim facilities is presented in the wet digestion subsection of Section X. A schematic flow diagram of a typical system is given in Figure 9 and is a basis for capital and operating cost estimates.

Treatment Cost Data

A profile of wet digester rubber reclaiming was made to ascertain the typical plant size. The typical, or average, plant is rated at 54,000 kilograms (110,000 pounds) per day. The process waste water flow generated by the dewatering liquor and condenser discharges was estimated to be approximately 392,000 liters per day (104,000 gpd) from plant visit data.

Designs for the control technology were costed in order to fully evaluate the economic impact of the recommended effluent limitations. The cited costs are based on the cases where no treatment facilities that could be modified yet exist, and no reduction or isolation measures for the containment of contaminated process waste waters have been taken. The design considerations (i.e., the raw waste loads) were selected to represent the expected raw waste loads. This results in the generation of cost data which should be conservative when applied to most of the plants in the wet digestion reclaimed rubber

	Control Technology[1]
Investment	$126,000
Annual Costs	
Capital Costs	12,600
Depreciation	25,200
Operating and Maintenance Costs (excluding energy and power costs)	19,300
Energy and Power Costs	4,700
Total Annual Costs	$ 61,800

Parameters kg/kkg(lb/1000 lb) of product	Raw Waste Loads	Effluent Quality
COD	9.75	6.11
SS	256.10	2.31
Oil	27.29	0.58

[1] The control technology includes recycle of dewatering liquor and decantation of vapor condensates followed by recycle of the oils and water underflow.

Table 24 - Estimated Waste Water Control Costs for a Wet Digestion Reclaim Plant (Subcategory H)

subcategory. Relatively conservative cost figures are preferred for this type of general economic analysis.

The capital costs were generated on a unit process basis, with the following "percent add on" figures applied to the total unit process costs in order to develop the total installed capital cost requirements:

Item	Percent of Unit Process Capital Cost
Electrical	15
Piping	20
Instrumentation	15
Site Work	10
Engineering Design and Supervision Construction	10
Construction Contingency	15

The total annual costs for the waste water control or recycle system can be developed in terms of incremental costs per unit weight of rubber reclaimed. The cost data presented for a typical wet digestion process of 54,000 kilograms per day indicate that the BPCTCA and BATEA technology will cost $0.004 per kilogram ($0.0019/lb) of production. These costs are based on six working days each week at 50 operating weeks per year.

Since land costs vary appreciably between plant locations, it was decided to exclude land cost from the total capital cost estimates. Land costs must be added on an individual case basis.

Annual costs were computed using the following cost basis:

Item	Cost Allocation
Capitalization	10 percent of investment
Depreciation	5-year straight line with zero salvage value.
Operations and Maintenance	Includes labor and supervision, chemicals, sludge hauling and disposals, insurance and taxes (computed at 1.6 percent of the total capital costs), and maintenance (3.2 percent of the total capital cost)

Power	Based on $0.015/kw-hr

The short-term capitalization and depreciation write-off period is what is currently acceptable under current Internal Revenue Service Regulations pertaining to industrial pollution control equipment. Economic analysis indicates other allowable methods of depreciation write-off are more advantageous. The annual costs presented in this document have therefore been overstated. The document, Economic Analysis of Effluent Guidelines The Rubber Processing Industry (Phase II), contains revised annual costs, reflecting optimum depreciation write-off.

All costs were computed in terms of August 1973 dollars which correspond to an Engineering News Record Index (ENR) value of 1920.

Energy Requirements

The waste water control and recycle system requires electrical energy for the operation of pumps and mixers. The power needs of the equipment are modest and approximate 48 horsepower.

Nonwater Quality Aspects

There are few nonwater quality aspects to be considered with this control technology. In order to employ the proposed technology, mechanical defibering is used. As a result the separated fibers are removed from the system as a solid waste, and dry air pollution control devices are required to remove fine fibrous emissions from the air. The costs associated with disposing of the fibrous solid waste are deemed minor in comparison with the treatment costs required to remove the fibrous material from the dewatering liquor in cases where chemical defibering is practiced.

Periodically it will be necessary to remove accumulated solids from the dewatering liquor storage tank. It is estimated that these solids will amount to less than 15 cubic meters (20 cubic yards) annually.

For those waste materials considered to be non-hazardous where land disposal is the choice for disposal, practices similar to proper sanitary landfill technology may be followed. The principles set forth in the EPA's Land Disposal of Solid Wastes Guidelines (CFR Title 40, Chapter 1; Part 241) may be used as guidance for acceptable land disposal techniques.

For those waste materials considered to be hazardous, disposal will require special precautions. In order to ensure long-term protection of public health and the environment, special preparation and pretreatment may be required prior to disposal. If land disposal is to be practiced, these sites must not allow movement of pollutants such as fluoride and radium-226 to either ground or surface water.

Sites should be selected that have natural soil and geological conditions to prevent such contamination or, if such conditions do not exist, artificial means (e.g., liners) must be provided to ensure long-term protection of the environment from hazardous materials. Where appropriate, the location of solid hazardous materials disposal sites should be permanently recorded in the appropriate office of the legal jurisdiction in which the site is located.

Pan (Heater), Mechanical, and Dry Digestion Rubber Reclaiming

The extent of the waste water problems and treatment types for all dry reclaiming processes can best be represented by those of the pan, or heater, reclaim process.

The waste water types are essentially similar to those produced by Subcategories E, F, and G plants with the additional contribution of the oven vapor condensates. The majority of the process wastes are created by spills and leaks in the cracking, grinding, and milling buildings as well as around material and fuel oil storage areas. The contaminants are principally oil and suspended solids. The vapor condensates contain organics vaporized from the rubber mix in the depolymerization oven.

The control and treatment approach proposed for this subcategory is isolation of the process waste waters preventing dilution of the contaminants and a decrease in their treatability. As for Subcategories E, F, and G wastes, the key to this type of control and treatment is the reduction and collection of the contaminated process waste waters prior to treatment for oil and suspended solids removal in an API-type separator. The separable organics in the depolymerization oven condensates can also be separated in the separator.

The anticipated effluent quality achieved by the proposed treatment is presented in Table 25 together with the associated cost data. In addition, a detailed description of the recommended technology is given in Section IX. Figure 10 is a schematic flow diagram of the required control and treatment facilities and is the basis for the indicated cost estimates.

Treatment Cost Data

The dry reclaiming industry was reviewed to determine an average or typical size for a pan process reclaiming plant. The selected size is 59,000 kilograms (130,000 pounds) per day of reclaimed rubber, and the corresponding process waste water flow rate is 283,000 liters (75,000 gallons) per day. The design flow rate was supported by the plant data obtained at the reclaiming plant visited.

	Treatment or Control Technology[1]	
	A	B
Investment[2]	$265,000	$277,000
Annual Costs		
Capital Costs	26,500	27,700
Depreciation	53,000	55,400
Operating and Maintenance Costs (excluding energy and power costs)	25,500	28,200
Energy and Power Costs	1,200	1,200
Total Annual Costs[2]	$106,200	$119,700

Parameters kg/kkg (lb/1000 lb) product	Raw Waste Loads	Effluent Quality	
		A	B
Suspended Solids	0.192	0.192	< 0.192
Oil and Grease	0.493	0.240	0.144

[1] Technology A is isolation of process waste waters followed by API gravity separation. Technology B is Technology A followed by a filter coalescer

[2] August 1973 dollars.

Table 25: Estimated Waste Water Treatment Costs at Different Degrees of Treatment for a Pan, Dry Digester, or Mechanical Reclaim Plant (Subcategory I)

The cited costs are based on the cases where no treatment facilities that could be modified yet exist, and no reduction or isolation measures for the containment of contaminated process waste waters have been taken. The design considerations (i.e., the influent raw waste loads) were selected to represent the expected raw waste load. This results in the generation of cost data which should be conservative when applied to most of the plants in this subcategory. Relatively conservative cost figures are preferred for this type of general economic analysis.

The capital costs were generated on a unit process basis, with the following "percent add on" figures applied to the total unit process costs in order to develop the total installed capital cost requirements:

Item	Percent of Unit Process Capital Cost
Electrical	12
Piping	15
Instrumentation	8
Site Work	5
Engineering Design and Construction Supervision Fees	10
Construction Contingency	15

Since land costs vary appreciably between plant locations, it was decided to exclude land cost from the total capital cost estimates. Land cost must be added on an individual case basis.

Annual costs were computed using the following cost basis.

Item	Cost Allocation
Capitalization	10 percent of investment.
Depreciation	5-year straight line with zero salvage value.
Operations and Maintenance	Includes labor and supervision, chemicals, sludge hauling and disposals, insurance and taxes (computed at 1.6 percent of the total capital costs), and maintenance (3.2 percent of the total capital cost)
Power	Based on $0.015 kw-hr for electrical power.

The short-term capitalization and depreciation write-off period is what is currently acceptable under current Internal Revenue Service Regulations pertaining to pollution control equipment. Economic analysis indicates other allowable methods of depreciation write-off are more advantageous. The annual costs presented in this document have therefore been overstated. The document, Economic Analysis of Effluent Guidelines The Rubber Processing Industry (Phase II), contains revised annual costs, reflecting optimum depreciation write-off.

All costs were computed in terms of August 1973 dollars, which correspond to an Engineering News Record Index (ENR) value of 1920.

Energy Requirements

The consumption of power and energy by the control and treatment system is minor and is limited to electrically operated pumps to pump process waste waters from the point sources within the plant through the treatment system. The total power needs of the facilities are approximately 12 horsepower.

Nonwater Quality Aspects

The primary nonwater quality effect created by the use of the proposed facilities is the need for disposal of oil and suspended solids collected in the separator. The total volume of wastes requiring disposal is estimated to be 172 cubic meters (230 cubic yards) per year which includes spent coalescer filters.

For those waste materials considered to be non-hazardous where land disposal is the choice for disposal, practices similar to proper sanitary landfill technology may be followed. The principles set forth in the EPA's Land Disposal of Solid Wastes Guidelines (CFR Title 40, Chapter 1; Part 241) may be used as guidance for acceptable land disposal techniques.

For those waste materials considered to be hazardous, disposal will require special precautions. In order to ensure long-term protection of public health and the environment, special preparation and pretreatment may be required prior to disposal. If land disposal is to be practiced, these sites must not allow movement of pollutants such as fluoride and radium-226 to either ground or surface water. Sites should be selected that have natural soil and geological conditions to prevent such contamination or, if such conditions do not exist, artificial means (e.g., liners) must be provided to ensure long-term protection of the environment from hazardous materials. Where appropriate, the location of solid hazardous materials disposal sites should be permanently recorded in the appropriate office of the legal jurisdiction in which the site is located.

Subcategories J and K -- Latex-Based Products

The latex-based products can be effectively separated into two subcategories. The first subcategory (Subcategory J) includes latex dipping, latex thread, and products manufactured in porous molds. The Subcategory K subcategory consists of latex foam manufacture. Since the required treatment is different for the two subcategories, separate discussions of the cost data are presented.

Subcategory J

Only one level of control and treatment has been considered in the evaluation of treatment effectiveness versus cost data. This recommended treatment includes chemical coagulation and primary clarification of latex-laden wastes followed by biological oxidation.

The biological treatment cost data have been based on an aerated lagoon and settling pond system. The reason for this selection is that the BOD concentration in the process waste waters is typically too low to support an activated sludge type biomass. Since the process wastes can be separated from the utility waste waters, the proposed treatment system is limited to the treatment of the process wastes.

Treatment Cost Data

A profile was made of the latex dipping industry to determine the typical size of a production facility. The average, or typical, plant has a daily consumption of 2,100 kilograms (4,700 pounds) of latex solids. The associated process waste water flow, derived from plant visit data, is 153,000 liters (40,000 gallons) per day.

The model treatment plant, consisting of chemical coagulation, clarification, and bio-oxidation is illustrated in Figure 11. This plant, equivalent to BPCTCA, is described more fully in Section IX.

The cited costs are based on the cases where no treatment facilities that could be modified yet exist, and no reduction or isolation measures for the containment of contaminated process waste waters have been taken. The treatment designs upon which the cost data are based correspond to the expected raw waste load. Relatively conservative cost figures are preferred for this type of general economic analysis.

The capital costs were generated on a unit process basis, with the following "percent add on" figures applied to the total unit process costs in order to develop the total installed capital cost requirements:

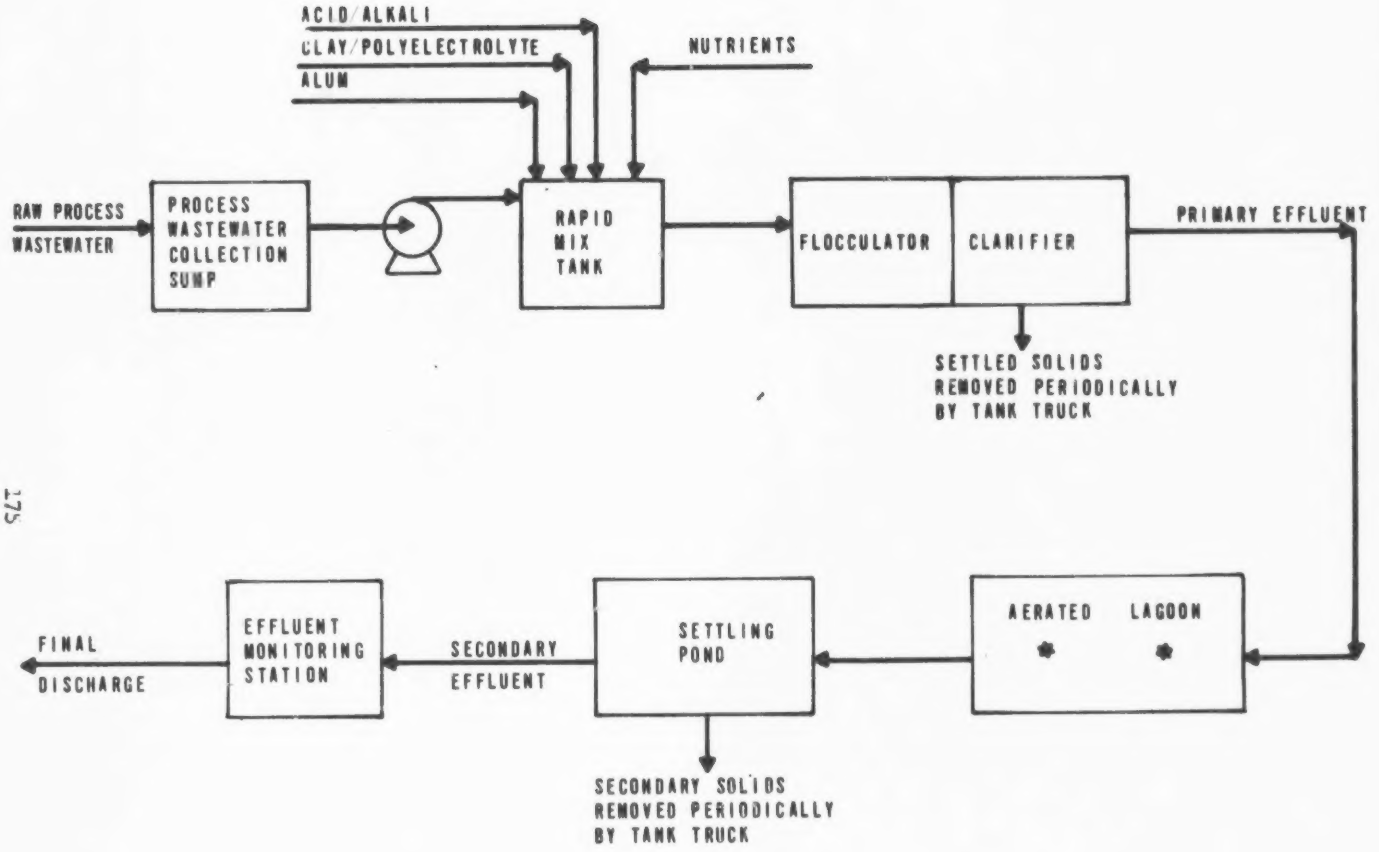
ACID/ALKALI
CLAY/POLYELECTROLYTE
ALUM
NUTRIENTS
RAW PROCESS WASTEWATER
PROCESS WASTEWATER COLLECTION SUMP
RAPID MIX TANK
FLOCCULATOR
CLARIFIER
PRIMARY EFFLUENT
SETTLED SOLIDS REMOVED PERIODICALLY BY TANK TRUCK
AERATED LAGOON
SETTLING POND
SECONDARY EFFLUENT
EFFLUENT MONITORING STATION
FINAL DISCHARGE
SECONDARY SOLIDS REMOVED PERIODICALLY BY TANK TRUCK

FIGURE 11: HYPOTHETICAL END-OF-PIPE SECONDARY WASTE WATER TREATMENT FACILITY FOR SUBCATEGORY J PLANTS

Item	Percent of Unit Process Capital Cost
Electrical	20
Piping	15
Instrumentation	8
Site Work	5
Engineering Design and Supervision Construction	10
Construction Contingency	15

The treatment costs incurred by the associated technology can be represented in terms of incremental costs per unit of production. Treatment cost data for a typical latex dipping plant consuming 2,100 kilograms (4,700 pounds) of latex solids per day indicate that the BPCTCA and BATEA treatment will cost $0.15 per kilogram ($0.069/lb) of latex solids usage.

Since land costs vary appreciably between plant locations, it was decided to exclude land cost from the total capital cost estimates. Land costs must be added on an individual case basis.

Annual costs were computed using the following cost basis:

Item	Cost Allocation
Capitalization	10 percent of investment
Depreciation	5-year straight line with zero salvage value.
Operations and Maintenance	Includes labor and supervision, chemicals, sludge hauling and disposals, insurance and taxes (computed at 1.6 percent of the total capital costs), and maintenance (3.2 percent of the total capital cost)
Power	Based on $0.015 kw-hr for electrical power.

The short-term capitalization and depreciation write-off period is what is currently acceptable under current Internal Revenue Service Regulations pertaining to industrial pollution control equipment. Economic analysis indicates other allowable methods of depreciation write-off are more advantageous. The annual costs presented in this document have therefore been overstated. The document, Economic Analysis of Effluent Guidelines The Rubber Processing Industry (Phase II), contains revised annual costs, reflecting optimum depreciation write-off.

All costs were computed in terms of August 1973 dollars, which correspond to an Engineering News Record Index (ENR) value of 1920.

The total capital and annual costs for the model treatment technologies are presented for a typical latex-dipping plant in Table 26, together with raw waste load and treated effluent quality.

Energy Requirements

The primary clarification and biological oxidation treatment technologies require electrical energy only for operation of equipment such as pumps and aerators. The power needs are low and will approximate 16 horsepower.

Nonwater Quality Aspects

The principal nonwater aspect of the proposed technology is the disposal of the primary coagulated latex solids and the infrequent removal of the biological solids from the settling pond. Both of these wastes will be removed most economically by contract disposal using a vacuum truck. The annual volumes of these wastes will approximate:

Primary Solids: 940 cubic meters (1,250 cu yds)
Biological Solids: 290 cubic meters (390 cu yds)

For those waste materials considered to be non-hazardous where land disposal is the choice for disposal, practices similar to proper sanitary landfill technology may be followed. The principles set forth in the EPA's Land Disposal of Solid Wastes Guidelines (CFR Title 40, Chapter 1; Part 241) may be used as guidance for acceptable land disposal techniques.

For those waste materials considered to be hazardous, disposal will require special precautions. In order to ensure long-term protection of public health and the environment, special preparation and pretreatment may be required prior to disposal. If land disposal is to be practiced, these sites must not allow movement of pollutants such as fluoride and radium-226 to either ground or surface water. Sites should be selected that have natural soil and geological conditions to prevent such contamination or, if such conditions do not exist, artificial means (e.g., liners) must be provided to ensure long-term protection of the environment from hazardous materials. Where appropriate, the location of solid hazardous materials disposal sites should be permanently recorded in the appropriate office of the legal jurisdiction in which the site is located.

	Control and Treatment Technology[1]
Investment	$236,700
Annual Costs	
Capital Costs	23,700
Depreciation	47,300
Operating and Maintenance Costs (excluding energy and power costs)	25,100
Energy and Power Costs	1,600
Total Annual Costs	$ 96,700

Parameters kg/kkg(lb/100 lb) of raw materials	Raw Waste Loads	Effluent Quality
BOD	18.2	2.20
Suspended Solids	10.90	2.90
Oil	0.90	0.73
Chromium	0.0533	0.0036

[1] The control and treatment technology includes chemical coagulation, clarification, biological oxidation, and secondary clarification.

Table 26 - Estimated Waste Water Control Costs for a Latex Dipped Plant (Subcategory J)

Subcategory K

Two levels of control and treatment have been studied in the evaluation of treatment cost and effectiveness. The first level of the proposed technology is chemical coagulation and clarification of latex-based wastes, as well as chemical precipitation and clarification of zinc-laden foam rinse waters. The second technology level proposed involves biological oxidation of the combined primary effluents. The biological treatment cost data are based on an activated sludge treatment system. This type of system was selected because the BOD loading of the combined effluent is high (approximately 400 mg/l) and would be able to support an active mixed liquor. The treatment cost is also based on a combined process effluent which includes the slightly contaminated barometric condenser flows. This waste stream has been included in the cost evaluation because the residual zinc concentration after chemical precipitation requires dilution by the condenser discharge in order to avoid biological inhibition.

Treatment Cost Data

The only significant latex foam plant in the United States was used as a basis for the industry. The plant has a daily consumption of 68,000 kilograms (150,000 pounds) of latex solids; the average process waste water flow is 1,608,000 liters (425,000 gallons) per day.

The model treatment plant, illustrating BPCTCA and BATEA, consists of chemical coagulation of latex solids, chemical precipitation of zinc, and biological oxidation. (See Figure 12.) This type of plant is described more fully in Sections IX and X.

The influent raw waste loads, upon which the treatment designs are based, represent the raw effluent conditions at the sole U.S. latex foam plant. This results in the generation of cost data which are the most appropriate for the subcategory as it is known to exist.

The total capital and annual costs for the model treatment techniques for the sole latex foam plant are presented in Table 27, together with the raw waste loads and treated effluent qualities.

The treatment costs for a latex foam production facility can be expressed as an incremental cost per unit of production. The cost data for a plant consuming 68,000 kilograms (150,000 pounds) of latex solids daily indicate that the BPCTCA and BATEA treatment will cost $0.015 per kilogram ($0.0068/lb) of latex consumption.

The capital costs were generated on a unit process basis, with the following "percent add on" figures applied to the total unit process costs in order to develop the total installed capital cost requirements:

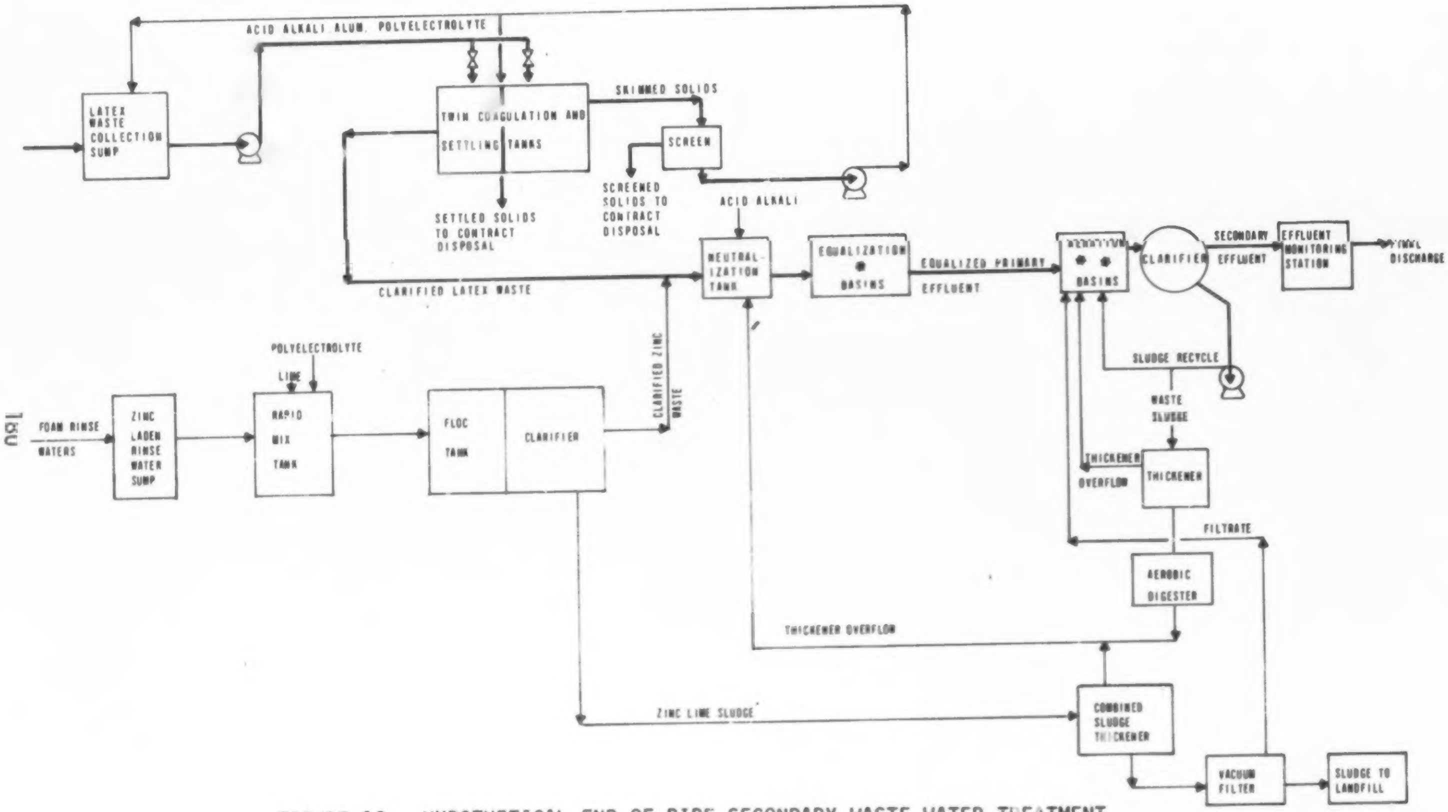
ACID ALKALI ALUM. POLYELECTROLYTE
LATEX WASTE COLLECTION SUMP
TWIN COAGULATION AND SETTLING TANKS
SKIMMED SOLIDS
SCREEN
SCREENED SOLIDS TO CONTRACT DISPOSAL
SETTLED SOLIDS TO CONTRACT DISPOSAL
ACID ALKALI
CLARIFIED LATEX WASTE
NEUTRALIZATION TANK
EQUALIZATION BASINS
EQUALIZED PRIMARY EFFLUENT
AERATION BASINS
CLARIFIER
SECONDARY EFFLUENT
EFFLUENT MONITORING STATION
FINAL DISCHARGE
SLUDGE RECYCLE
WASTE SLUDGE
THICKENER OVERFLOW
THICKENER
FILTRATE
AEROBIC DIGESTER
THICKENER OVERFLOW
POLYELECTROLYTE
LIME
FOAM RINSE WATERS
ZINC LADEN RINSE WATER SUMP
RAPID MIX TANK
FLOC TANK
CLARIFIER
CLARIFIED ZINC WASTE
ZINC LIME SLUDGE
COMBINED SLUDGE THICKENER
VACUUM FILTER
SLUDGE TO LANDFILL

FIGURE 12: HYPOTHETICAL END-OF-PIPE SECONDARY WASTE WATER TREATMENT FACILITY FOR SUBCATEGORY K PLANTS

	Treatment of Control Technology[1]	
	A	B
Investment[2]	$348,000	649,000
Annual Costs		
Capital Costs	34,800	65,000
Depreciation	69,600	129,800
Operating and Maintenance Costs (excluding energy and power costs)	55,300	98,400
Energy and Power Costs	3,500	13,100
Total Annual Costs[2]	$163,200	$306,300

Parameters kg/kkg(lb/1000 lb) of raw materials	Raw Waste Loads	Effluent Quality	
		A	B
BOD	20.44	9.43	1.41
Suspended Solids	8.71	1.60	0.94
Zinc	3.54	0.083	0.083

[1] Technology A is chemical coagulation and clarification of latex waste waters and chemical precipitate and clarification of zinc-laden waste waters. Technology B is Technology A followed by biological oxidation treatment.

[2] August 1973.

Table 27 - Estimated Waste Water Treatment Costs at Different Degrees of Treatment for a Latex Foam Plant (Subcategory K)

Item	Percent of Unit Process Capital Cost
Electrical	12
Piping	15
Instrumentation	8
Site Work	3
Engineering Design and Construction Supervision Fees	10
Construction Contingency	15

Since land costs vary appreciably between plant locations, it was decided to exclude land cost from the total capital cost estimates. Land costs must be added on an individual case basis.

Annual Costs were computed using the following cost basis:

Item	Cost Allocation
Capitalization	10 percent of investment
Depreciation	5-year straight line with zero salvage value
Operations & Maintenance	Includes labor and supervision, chemicals, sludge hauling and disposal, insurance and taxes (computed at 1.6 percent of the total capital cost), and maintenance (3.2 percent of the total capital cost)
Power	Based on $0.015 kw-hr for electrical power.

The short-term capitalization and depreciation write-off period is what is currently acceptable under current Internal Revenue Service Regulations pertaining to pollution control equipment. Economic analysis indicates other allowable methods of depreciation write-off are more advantageous. The annual costs presented in this document have therefore been overstated. The document, Economic Analysis of Effluent Guidelines The Rubber Processing Industry (Phase II), contains revised annual costs, reflecting optimum depreciation write-off.

All costs were computed in terms of August 1973 dollars, which correspond to an Engineering News Record Index (ENR) value of 1920.

Energy Requirements

Energy usage is related to the need for electric pumps to move waste waters through the treatment system and for several agitator and aerator systems. The extra power required for treatment and control systems is minor and is estimated to be 134 HP.

Nonwater Quality Aspects

The main nonwater effect of the model treatment system is the disposal of the primary chemical treatment solids wastes and the synthesized biological solids. The most feasible ultimate disposal of these filtered and stabilized solid wastes is landfill. The annual volumes of these waters is calculated to be:

Primary Solids: 2,000 cubic meters (1,500 cu yds)
Biological Solids: 800 cubic meters (600 cu yds)

For those waste materials considered to be non-hazardous where land disposal is the choice for disposal, practices similar to proper sanitary landfill technology may be followed. The principles set forth in the EPA's Land Disposal of Solid Wastes Guidelines (CFR Title 40, Chapter 1; Part 241) may be used as guidance for acceptable land disposal techniques.

For those waste materials considered to be hazardous, disposal will require special precautions. In order to ensure long-term protection of public health and the environment, special preparation and pretreatment may be required prior to disposal. If land disposal is to be practiced, these sites must not allow movement of pollutants such as fluoride and radium-226 to either ground or surface water. Sites should be selected that have natural soil and geological conditions to prevent such contamination or, if such conditions do not exist, artificial means (e.g., liners) must be provided to ensure long-term protection of the environment from hazardous materials. Where appropriate, the location of solid hazardous materials disposal sites should be permanently recorded in the appropriate office of the legal jurisdiction in which the site is located.

Detailed Cost Information for All Subcategories

Tables 28 through 43 contain detailed cost information used to develop the total capital and annual costs for best practicable control technology currently available (BPCTCA) and best available technology economically achievable (BATEA) treatment systems presented and discussed in Sections VIII, IX and X of this report.

Daily Raw Material Consumption = 900 kg (2,000 lbs.)

Estimated Process Effluent Flow = 14,700 L/day (3,900 gpd)

Description of Treatment Facility	Estimated Capital Costs
Sewer Segregation[1]	$ 7,200
Process Sumps and Pumps	20,900
Process Waste Water Force Main	1,400
Filter	2,300
Process Effluent Sewer and Monitoring Station	10,100
Sub-Total	$41,900
Site Work	4,200
Electrical	6,300
Piping	8,400
Instrumentation	6,300
Sub-Total	$67,100
Engineering Fees	6,700
Contingency	10,200
Total Capital Cost (Investment)[2]	$84,000

[1] Includes sealing existing floor drains, installation of new process drains, and oily waste water retainment curbing.

[2] Land costs are not included.

Table 28 - BPCTCA and BATEA Treatment Capital Costs for a Typical Small-Sized Molded, Extruded or Fabricated Rubber Plant (Subcategory E)

Daily Raw Material Consumption = 7,700 kg (17,000 lbs.)

Estimated Process Effluent Flow = 75,800 L/day (20,000 gpd)

Description of Treatment Facility	Estimated Capital Costs
In-plant Sewer Segregation[1]	$ 13,900
In-plant Process Sumps and Pumps	31,300
Process Waste Water Force Main	10,300
Outdoor Waste Water Segregation System[2]	6,300
Outdoor Process Sumps	10,000
Oil Separator	11,100
Filter	4,600
Process Effluent Sewer and Monitoring Station	10,100
Sub-Total	$ 97,600
Site Work	4,900
Electrical	11,700
Piping	14,600
Instrumentation	7,800
Sub-Total	$136,600
Engineering Fees	13,700
Contingency	20,700
Total Capital Cost (Investment)[3]	$171,000

[1] Includes sealing existing floor drains, installation of new process drains, and oily waste water retainment curbing.

[2] Includes roofing, curbing, and process waste water drains.

[3] Land costs are not included.

Table 29 - BPCTCA and BATEA Treatment Capital Costs for a Typical Medium-Sized Molded, Extruded or Fabricated Rubber Plant (Subcategory F)

Daily Raw Material Consumption = 15,400 kg (34,000 lbs.)

Estimated Process Effluent Flow = 95,900 L/day (25,300 gpd)

Description of Treatment Facility	Estimated Capital Costs
In-plant Sewer Segregation[1]	$ 22,400
In-plant Process Sumps and Pumps	41,700
Process Waste Water Force Main	17,700
Outdoor Waste Water Segregation System[2]	11,000
Outdoor Process Sumps	10,000
Oil Separator	7,800
Filter	6,900
Process Effluent Sewer and Monitoring Station	10,100
Sub-Total	$127,600
Site Work	6,400
Electrical	15,300
Piping	19,000
Instrumentation	10,100
Sub-Total	$178,400
Engineering Fees	17,800
Contingency	26,800
Total Capital Cost (Investment)[3]	$223,000

[1] Includes sealing existing floor drains, installation of new process drains and oily waste water retainment curbing.

[2] Includes roofing, curbing, and process waste water drains and sewers.

[3] Land costs are not included.

Table 30 - BPCTCA and BATEA Treatment Capital Costs for a Typical Large-Sized Molded, Extruded or Fabricated Rubber Plant (Subcategory G)

Daily Production Capacity = 54,000 kg (110,000 lbs.)

Estimated Process Effluent Flow = 392,000 L/day (104,000 gpd)

Description of Control/Treatment Unit	Estimated Capital Cost
Primary Oil Decant Tank	$ 8,800
Waste Oil Pumps	2,800
Waste Oil Storage Tank	5,900
Waste Oil Storage Pump	2,800
Waste Water Storage Tank	12,700
Waste Water Tank Mixer	14,100
Waste Water Tank Discharge Pump	4,100
Waste Water Return Pump	1,400
Monitoring Station	10,400
Sub-Total	$ 63,000
Site Work	6,300
Electrical	9,500
Piping	12,600
Instrumentation	9,500
Sub-Total	$100,900
Engineering Fees	10,100
Contingency	15,000
Total Capital Cost (Investment)[1]	$126,000

[1] Land costs are not included.

Table 31 - BPCTCA and BATEA Treatment Costs for a Typical Wet Digestion Rubber Reclaiming Plant (Subcategory H)

Daily Raw Material Consumption = 59,000 kg (130,000 lbs.)

Estimated Process Effluent Flow = 283,400 L/day (74,900 gpd)

Description of Treatment Facility	Estimated Capital Costs
In-plant Sewer Segregation[1]	$ 44,600
In-plant Process Sumps and Pumps	28,400
Process Waste Water Force Main	22,500
Outdoor Waste Water Segregation System[2]	19,100
Outdoor Process Sumps	10,000
Oil Separator	16,500
Filter	6,900
Process Effluent Sewer and Monitoring Station	10,100
Sub-Total	$158,100
Site Work	7,900
Electrical	19,000
Piping	23,700
Instrumentation	12,600
Sub-Total	$221,300
Engineering Fees	22,200
Contingency	33,500
Total Capital Cost (Investment)[3]	$277,000

[1] Includes sealing existing floor drains, installation of new process drains, and oily waste water retainment curbing.

[2] Includes roofing, curbing, and process waste water drains and sewers.

[3] Land costs are not included.

Table 32 - BPCTCA and BATEA Treatment Capital Costs for a Typical Pan, Dry Digester or Mechanical Reclaim Plant (Subcategory I)

Daily Latex Solids Consumption = 2,100 kg (4,700 lbs.)

Estimated Process Effluent Flow = 153,000 L/day (40,000 gpd)

Description of Treatment Unit	Estimated Capital Cost
Collection Sump and Pumps	$ 7,300
pH Adjustment and Coagulant Feed	14,800
Mix nd Flocculation Tanks	4,700
Clarifier	18,400
Aerated Lagoon	27,300
Aerators	16,600
Settling Pond	36,000
Monitoring Station	10,400
Sub-Total	$135,500
Site Work	6,800
Electrical	26,300
Piping	20,000
Instrumentation	10,800
Sub-Total	$189,400
Engineering Fees	18,900
Contingency	28,400
Total Capital Cost (Investment)[1]	$236,700

[1] Land costs not included.

Table 33 - BPCTCA and BATEA Treatment Capital Costs for a Typical Latex Dipping Production Facility (Subcategory J)

Daily Latex Solids Consumption = 68,000 kg (150,000 lbs)

Estimated Process Effluent Flow = 1,608,000 L/day (425,000 gpd)

Description of Treatment Unit	Estimated Capital Cost
Latex Collection Sump and Pumps	$ 5,800
pH Adjustment and Coagulant Feed	1,200
Latex Coagulation Tanks	37,500
Zinc Collection Sump and Pumps	7,600
Lime Slurry Tank	1,600
Zinc Mixer and Flocculator-Clarifier	40,000
Thickener	41,200
Vacuum Filter and Solids Handling Equipment	48,500
Monitoring Station	15,000
Sub-Total	$198,400
Site Work	9,900
Electrical	23,900
Piping	29,900
Instrumentation	15,900
Sub-Total	$278,000
Engineering Fees	28,000
Contingency	42,000
Total Capital Costs (Investment)[1]	$348,000

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[1] Land costs are not included.

Table 34 - Technology A Capital Costs for a Typical Latex Foam Plant (Subcategory K)

Daily Latex Solids Consumption = 68,000 kg (150,000 lbs)

Estimated Process Effluent Flow = 1,608,000 L/day (425,000 gpd)

Description of Treatment Unit	Estimated Capital Costs
Equalization Basins	$ 85,700
Aeration Basins	103,500
Clarifier	100,400
Thickener	22,400
Aerobic Digester	58,800
Sub-Total	$370,800
Site Work	18,500
Electrical	44,500
Piping	55,600
Instrumentation	29,700
Sub-Total	$519,100
Engineering Fees	51,900
Contingency	78,000
Total Capital Costs (Investment)[1]	$649,000

[1] Land costs are not included.

Table 35 - Technology B Capital Costs for a Typical Latex Foam Plant (Subcategory K)

Daily Raw Material Consumption = 900 kg (2,000 lbs.)

Estimated Process Effluent Flow = 14,700 L/day (3,900 gpd)

Description of Cost Item	Annual Cost
Absorbent	$ 800
Sludge Disposal	700
Labor	6,300
Power and Energy	600
Maintenance	3,400
Insurance and Taxes	1,700
Total Annual Operating and Maintenance Cost	$13,500

Table 36 - BPCTCA and BATEA Operating and Maintenance Costs for a Typical Small-Sized Molded, Extruded or Fabricated Rubber Plant (Subcategory E)

Daily Raw Material Consumption = 7,700 kg (17,000 lbs.)

Estimated Process Effluent Flow = 75,800 L/day (20,000 gpd)

Description of Cost Item	Annual Cost
Absorbent	$ 3,900
Sludge Disposal	2,300
Labor	6,300
Power and Energy	800
Maintenance	7,100
Insurance and Taxes	3,600
Total Annual Operating and Maintenance Costs	$24,000

Table 37 - BPCTCA and BATEA Operating and Maintenance Costs for a Typical Medium-Sized Molded, Extruded or Fabricated Rubber Plant (Subcategory F)

Daily Raw Material Consumption = 15,400 kg (34,000 lbs.)

Estimated Process Effluent Flow = 95,900 L/day (25,300 gpd)

Description of Cost Item	Annual Cost
Absorbent	$ 4,900
Sludge Disposal	3,300
Labor	6,300
Power and Energy	1,200
Maintenance	8,800
Insurance and Taxes	4,500
Total Annual Operating and Maintenance Cost	$29,000

Table 38 - BPCTCA and BATEA Operating and Maintenance Costs for a Typical Large-Sized Molded, Extruded or Fabricated Rubber Plant (Subcategory G)

Daily Production Capacity = 54,000 kg (110,000 lbs.)

Estimated Process Effluent Flow = 392,000 L/day (104,000 gpd)

Description of Cost Item	Annual Cost
Sludge Disposal	$ 4,500
Labor	8,800
Power and Energy	4,700
Maintenance	4,000
Insurance and Taxes	2,000
Total Annual Operating and Maintenance Cost	$24,000

Table 39 - BPCTCA and BATEA Operating and Maintenance Costs for a Typical Wet Digestion Rubber Reclaiming Plant (Subcategory H)

Daily Raw Material Consumption = 59,000 kg (130,000 lbs.)

Estimated Process Effluent Flow = 283,400 L/day (74,900 gpd)

Description of Cost Item	Annual Cost
Absorbent	$ 4,700
Sludge Disposal	3,900
Labor	6,300
Power and Energy	1,200
Maintenance	8,900
Insurance and Taxes	4,400
Total Annual Operating and Maintenance Costs	$29,400

Table 40 - BPCTCA and BATEA Operating and Maintenance Costs for a Typical Pan, Dry Digester or Mechanical Reclaim Plant (Subcategory I)

Daily Latex Solids Consumption = 2,100 kg (4,700 lbs.)

Estimated Process Effluent Flow = 153,000 L/day (40,000 gpd)

Description of Cost Item	Annual Cost
Chemicals	$ 1,900
Sludge Disposal	3,000
Labor	8,800
Power and Energy	1,600
Maintenance	7,600
Insurance and Taxes	3,800
Total Annual Operating and Maintenance Cost	$26,700

Table 41 - BPCTCA and BATEA Operating and Maintenance Costs for a Typical Latex Dipping Production Facility (Subcategory J)

Daily Latex Solids Consumption = 68,000 kg (150,000 lbs)

Estimated Process Effluent Flow = 1,608,000 L/day (425,000 gpd)

Description of Cost Item	Annual Cost
Chemicals	$24,100
Sludge Disposal	3,300
Labor	11,200
Power and Energy	3,500
Maintenance	11,100
Insurance and Taxes	5,600
Total Annual Operating and Maintenance Cost	$58,800

Table 42 Technology A Operating and Maintenance Cost for a Typical Latex Foam Production Facility (Subcategory K)

Daily Latex Solids Consumption = 68,000 kg (150,000 lbs)

Estimated Process Effluent Flow = 1,608,000 L/day (425,000 gpd)

Description of Cost Item	Annual Cost
Sludge Disposal	$ 800
Labor	11,100
Power and Energy	9,600
Maintenance	20,800
Insurance and Taxes	10,400
Total Annual Operating and Maintenance Costs	$52,700

Table 43 - Technology B Operating and Maintenance Cost for a Typical Latex Foam Production Facility (Subcategory K)

SECTION IX

BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE - EFFLUENT LIMITATIONS

General Molded, Extruded and Fabricated Rubber Subcategories

The best control and treatment technologies currently in use at molded, extruded, or fabricated production facilities emphasize in-plant housekeeping and control measures. In-plant techniques varied widely from plant to plant. In general, they included the isolation of potential waste water sources with retainment curbing, the elimination of drains in contaminated areas, and the use of sumps to collect isolated process waste water streams. The model treatment technology for a typical plant is a combination of the best features of the various plants examined. It is similar for all three size subcategories.

Basically, the technology consists of:

1. Eliminating anti-tack or latex solution discharge.
2. Isolation, control, and treatment of all oily waste streams.

A flow diagram of the model treatment system is shown in Figure 10.

Previous experience with the tire and inner tube industry indicates that zero discharge of anti-tack solutions is widely practiced. Since this waste water problem is common to Subcategories E, F, and G facilities, it is considered a feasible practice for all Subcategories E, F, and G facilities to attain zero discharge of anti-tack solutions by adhering to the following procedures:

1. Recycle of anti-tack solution.
2. Installation of curbing around the anti-tack dipping area.
3. Sealing of drains in the dipping area.
4. Reuse of the recirculating system wash water as make-up for fresh anti-tack solution.

The reuse of recirculating system wash water is the key to zero discharge of this waste. In emptying the system for cleaning, the anti-tack solution should be stored in tanks. The wash water used should also be collected and stored. Once the system is cleaned, stored anti-tack can then be returned to the system for use in the new production batch. The collection and stored wash water can then be reused as make-up water for the anti-tack bath during the normal production run.

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Elimination of latex discharges from fabricated products facilities is achieved by:

1. The use of curbing around latex storage and transfer areas.
2. The sealing of all drains in latex use areas.
3. The containment of all latex-contaminated waste streams.

It is normal for latex-using facilities to buy latex in bulk and then store it in drums as needed, for use within the plant. The drums normally need to be stripped clean of latex after every use. When water is used, a waste water is generated. This stream has to be containerized to eliminate discharge of latex. However, it has been demonstrated that wash waters emanating from this area are eliminated when plastic drum liners are used. The liners are discarded after each drum use.

Control and treatment of oily waste streams involves segregation, collection, and treatment of these wastes. The wastes to be segregated include runoff from oil storage and unloading areas and leakage and spills in the process areas, as shown in Figure 10. Press and mill basins, when present, are included in the process area.

To minimize the raw waste load, all process water should be isolated from the nonprocess waste water used in the plant. This can be achieved by diverting drippings from heavy machinery in the molding and curing areas to sumps. These waste flows are intermittent by nature and, therefore, sizeable flow rates will hardly ever be obtained without first collecting all wastes in centralized locations. Waste waters collected in these sumps will be periodically pumped to an API-type gravity separator, where the separable oil and solids fraction is removed. The waste water can be either pumped to the treatment system or collected in batches and hauled to a treatment or disposal area. The latter method should be used only when it is shown to be unfeasible to rip out and install new sewer lines.

In the medium and large plants, separated oil is removed by a belt skimmer. A decant drum is provided to allow water removed with the oil to settle out. Concentrated oil-water mixtures are then removed from the decant tank, drummed, sealed, and disposed of. Water removed from the tank is pumped back to the separator. Settled solids collected in the separator are periodically removed and disposed of. Additional treatment for oil and suspended solids removal is obtained by passing the separator effluent through an filter coalescer. In the small plants, the waste water flow rates and loadings are low. This allows the waste streams to be pumped directly from the collection sumps to the filter. Oil and suspended solids which might be separated in the sump are manually removed. The possibility exists that a high suspended solids loading may cause clogging of filter coalescers. In-plant controls should be capable of yielding significantly lower suspended solids loadings than 40 mg/l, however, some cases may exist where this would be difficult. Alternatives do exist; strict in-plant controls to prevent oil and grease spills and leaks can result in compliance with the regulation, or an alternative treatment system such as dissolved air flotation or dispersed air flotation can be utilized to comply with the limitations.

For plants manufacturing hose via lead-sheathed processes, an additional parameter, lead, can be a significant pollutant with respect to the plant's waste water effluent. Lead enters the curing condensate by being scavanged from the lead-sheathing; resulting in a lead concentration of approximately 60 mg/l within the condensate. The flow rate of condensate is small, approximately 1 gpm, therefore proper treatment involves segregation of the condensate followed by treatment. Other possible streams may also contain significant amounts of lead. These are the lead press and cured hose cooling waters. If these streams exist they also should be segregated and treated. Methods of control are pre-coat filtration, and recycle through a cooling tower (with treatment of the blowdown via primary settling).

Numerous plants within Subcategories E, F, and G, have metal parts within the final product. Various metal finishing processes may occur at the plant or metal parts maybe purchased ready for use. In the case of a rubber manufacturer which conducts their own metal preparations, the effluent from these processes will be appropriately covered by metal finishing guidelines.

Effluent Loadings Attainable with the Control Technology

Although the model treatment technologies for each subcategory are similar, the effectiveness of the system will vary according to the flow and loadings and, therefore, the size subcategory.

Subcategory E: Small-Sized Production Facilities

Based on the control technology data obtained from general molded extruded, or fabricated rubber manufacturing sources, and treatment data obtained from industries having similar waste water problems, it was determined that the control and treatment technologies are compatible with the following thirty day average effluent quality for small-sized molded, extruded and fabricated rubber production facilities:

Suspended Solids	40 mg/l
Oil and Grease	15 mg/l
Lead	0.1 mg/l
pH	6.0 to 9.0

Effluent quality is best expressed in terms of the waste load per unit of raw material consumed and is thereby independent of the flow and relative size of the plant. Limitations for BPCTCA are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	0.70	0.25
TSS	1.28	0.64
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Oil and grease	0.70	0.25
TSS	1.28	0.64
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to lead-sheathed hose production are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Lead	0.0017	0.0007
(English units)	lb/1000 lb of raw material	
Lead	0.0017	0.0007

For plants utilizing wet scrubbers, an additional allowance for TSS is as follows:

Effluent Characteristic	Effluent Limitations

	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	5.8	2.9
(English units)	lb/1000 lb of raw material equivalent	
TSS	5.8	2.9

Only one of the two small plants visited is currently achieving the standard for oil. Both small plants are achieving the standard for suspended solids.

Subcategory F: Medium-Sized Production Facilities

The control and treatment technologies are compatible with the following thirty day average effluent quality for medium-sized molded, extruded and fabricated rubber production facilities:

Suspended Solids	40 mg/l
Oil and Grease	15 mg/l
Lead	0.1 mg/l
pH	6.0 to 9.0

It is expected that the use of an API separator will result in an effluent oil concentration of approximately 30 mg/l (possibly higher concentrations should be damped by secondary oil and grease treatments). The use of a filter coalescer should further reduce the effluent oil concentration to 15 mg/l. Literature on filter coalescers indicates that 15 mg/l is readily attainable. A reduction of suspended solids to 40 mg/l will result from the use of an API separator. Additional reduction appears likely after passage through the filter coalescer.

Effluent quality is best expressed in terms of the waste load per unit of raw material consumed and is thereby independent of the flow and relative size of the plant. Limitation for BPCTCA are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty

		consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	0.42	0.15
TSS	0.80	0.40
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Oil and grease	0.42	0.15
TSS	0.80	0.40
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to lead-sheathed hose production are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Lead	0.0017	0.0007
(English units)	lb/1000 lb of raw material	
Lead	0.0017	0.0007

For plants utilizing wet scrubbers, an additional allowance for TSS is as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	5.8	2.9

(English units)	lb/1000 lb of raw material equivalent	
TSS	5.8	2.9

All the medium-sized plants visited are currently achieving the standard for both oil and suspended solids (according to sampling analysis conducted by the EPA contractor).

Subcategory G: Large-Sized Production Facilities

The control and treatment technologies are compatible with the following thirty day average effluent quality for large-sized molded, extruded and fabricated rubber production facilities:

Suspended Solids	40 mg/l
Oil and Grease	15 mg/l
Lead	0.1 mg/l
pH	6.0 to 9.0

Effluent quality is best expressed in terms of the waste load per unit of raw material consumed and is thereby independent of flow and size variations within the overall size subcategory. Limitations for BPCTCA are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	0.26	0.093
TSS	0.50	0.25
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Oil and grease	0.26	0.093
TSS	0.50	0.25
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to lead-sheathed hose production are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Lead	0.0017	0.0007
(English units)	lb/1000 lb of raw material	
Lead	0.0017	0.0007

For plants utilizing wet scrubbers, an additional allowance for TSS is as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	5.8	2.9
(English units)	lb/1000 lb of raw material equivalent	
TSS	5.8	2.9

Two of the four large-sized plants visited are currently achieving the standards for suspended solids.

Wet Digestion Reclaimed Rubber Subcategory

Identification of Best Practicable Control Technology Currently Available

Wet digestion rubber reclaiming is a declining industry and currently only three known plants remain. The wet digestion process is essentially phasing out with some of the wet digester reclaimed rubber production being taken up by the dry reclaiming processes.

Of the existing wet digestion plants, all except one discharge contaminated process waste waters to local municipal treatment systems. The one exception utilizes a waste stream recycle and reclaim system which appreciably reduces the waste water loadings prior to direct discharge. This plant is currently undergoing plans to also discharge to a municipal treatment system.

Only minor waste water quality improvements can be achieved by the good housekeeping and waste control because the greatest proportion of waste water contamination is generated by the dewatering-liquor waste stream and not by spills, leaks, and washdowns.

Limitations for BPCTCA are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of product	
COD	14.7	6.11
Oil and grease	0.40	0.144
TSS	1.04	0.52
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of product	
COD	14.7	6.11
Oil and grease	0.40	0.144
TSS	1.04	0.52
pH	Within the range 6.0 to 9.0.	

Pan (Heater), Mechanical and Dry Digestion Reclaimed Rubber Subcategory

Identification of Best Practicable Control Technology Currently Available

Currently, the most common method of treating wastes from Subcategory I reclaim facilities is to discharge to municipally operated treatment systems. In-house efforts to control the pollution-producing aspects of the facilities have been directed mainly toward air emission problems. Water pollution problems have not been considered a major problem. Therefore, the proposed treatment technology for a typical Subcategory I reclaim plant is the same as that used in other industries having similar waste water problems. It is very similar to the technologies proposed for Subcategories E, F, and G.

As before, the technology employed consists basically of:

1. Eliminating anti-tack solution discharge.
2. Segregation, control and treatment of all oily waste.

The flow diagram is the same as presented for Subcategories E, F, and G and is presented in Figure 10. The anti-tack solution discharges are eliminated by recycling. Wash waters are also reused. Oily waste streams are segregated, collected and treated. Segregation involves blocking existing drains in contaminated areas and installing retainment curbing. Once segregated, the waste streams are collected in sumps. The waste water is treated in an API separator and an filter coalescer medium. For a detailed discussion of the proposed system, refer to the related paragraphs dealing with Subcategories E, F, and G.

Effluent Loadings Attainable with the Control Technology

Based on the control technology obtained from reclaim sources and data obtained from industries having similar waste water problems, the control and treatment technologies are deemed compatible with the following thirty day average effluent quality for pan (heater), dry digester or mechanical reclaim facilities.

Suspended Solids	40 mg/l
Oil and Grease	30 mg/l
pH	6.0 to 9.0

It is expected that the use of an API separator and a filter coalescer will result in an effluent oil concentration of 30 mg/l. The higher concentration of oil and grease allowed for rubber reclaiming is due to the use of light soluble oils utilized in rubber reclaiming.

A reduction of suspended solids to 40 mg/l will result from the use of the API separator. Additional reduction appears likely after passage through a filter coalescer.

Effluent limitation for BPCTCA, expressed in terms of waste load per unit of raw material consumed are as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed

(Metric units)	kg/kkg of product	
Oil and grease	0.40	0.144
TSS	0.384	0.192
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of product	
Oil and grease	0.40	0.144
TSS	0.384	0.192
pH	Within the range 6.0 to 9.0.	

The following COD limitations may apply to pan, dry digestion, and mechanical reclaimed rubber processes integrated with a wet digestion process.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of product	
COD	6.7	2.8
(English units)	lb/1000 lb of product	
COD	6.7	2.8

Subcategories J and K -- Latex-Based Products

The principal difference in the waste water characteristics found at latex-based manufacturing facilities and those of the other subcategories studied in this document, is the presence of substantial quantities of uncoagulated latex solids in Subcategories J and K waste waters Subcategory J plants include latex-dipped goods, latex thread, and products made in porous molds. The one latex foam plant in existence constitutes Subcategory K.

Subcategory J

All latex-bearing waste waters should be passed through a chemical coagulation and clarification primary stage of treatment. In this process the latex is coagulated to form solid rubber. Treatability studies will determine whether a "sinker" such as clay is required to weight down the coagulated solids or whether their buoyancy will allow them to be skimmed from the clarifier.

The first unit of this treatment is a rapid mix tank where the waste water pH is adjusted to facilitate coagulation. The coagulating chemicals, alum and polyelectrolyte are added to the tank. The tank contents are vigorously mixed to bring together the coagulating chemicals and the latex solids. Waste water then flows to a flocculation tank where the coagulation process is completed with mild mixing in order to create a separate solids floc. The mixture of flocculated solids and waste water passes to the clarifier where the coagulated solids separate from the waste water. If a "sinker", such as clay, is required the solids will settle to the bottom of the clarifier where they can be drawn off, and the clarifier waste stream will overflow. If, on the other hand, the latex solids float and separate readily, the coagulated latex will be skimmed from the surface of the clarifier and the clarified waste water will underflow from clarifier.

The most practicable technique for disposing the small quantities of coagulated latex solids resulting from this treatment is by contracting for the transport of the residual wastes to a final disposal site. In the case of the sinking solids these can be pumped from the clarifier to a sludge dewatering bed from where they can be collected periodically by the disposal contractor. For the skimmed latex solids, the skimming can be first passed to a screen where the bulk of the water is removed and returned to the treatment system. The screened solids can then be containerized.

The clarified waste stream passes from the clarifier into an aerated lagoon where it is mixed with biological solids. Microorganisms synthesize new biological solids from organic matter contained in the waste water. At the same time, some soluble matter is consumed for energy purposes using oxygen supplied by the aerators in the lagoon. The net result is that soluble matter is converted into insoluble biological solids which can be separated from the waste water thereby reducing the soluble BOD of the waste water. Treatability studies and waste water analyses will determine if the nutrient addition, if necessary, can be made in the rapid mix tank.

The mixture of waste water and biological solids in the aerated lagoon overflows from the lagoon to a settling pond where the biological solids settle out and additional biological stabilization of the waste water occurs. The settled solids are removed periodically, say twice a year, from the pond. The most feasible and practicable method involves the employment of a contract hauler's vacuum truck or equivalent apparatus. The clarified waste water from the settling pond overflows to an effluent monitoring station, where the waste water flow, temperature, and pH are recorded and an automatic 24-hour composite sample is collected.

A biological treatment system composed of an aerated lagoon and settling pond is proposed for Subcategory J facilities since the BOD levels in this waste water are too low to support a good, settleable biomass in an activated sludge treatment facility. The proposed treatment is illustrated schematically in Figure 11.

The above description discusses primarily the treatment of latex-laden wastes. Non-latex waste waters which require only secondary biological treatment, such as product rinse waters, should be routed to the aerated lagoon, bypassing the coagulation and clarification system. This approach will enhance the treatability of the latex wastes and reduce the size of coagulation-clarification facilities by preventing unnecessary dilution.

It should be noted that the latex-laden wastes can be reduced and potentially eliminated by careful housekeeping and good latex handling practices. Excessive washdown and cleaning waters should be avoided when dealing with latex spills. Latex spills can often be coagulated _in situ_, with alum or other coagulants, and removal as a solid mass by shoveling and scraping. Plastic drum liners can be used to eliminate pollutants from entering the waste waters during drum cleaning. The benefits, in treatment costs and effluent quality, created by these and other techniques are appreciable.

A few latex-dipping operations generate waste waters which require additional control and treatment techniques. These techniques are not included in the cost data presented in Section VIII since they are not representative of the processes used by the majority of the latex-based manufacturing facilities. Form-cleaning wastes, such as chromic acid-laden rinse waters, should be eliminated by the use of alternative cleaning techniques believed to be feasible in almost all cases. If the chromic acid cleaning technique cannot be replaced, then chromium chemical reduction and precipitation procedures are required.

Subcategory K

The BPCTCA treatment for the latex foam industry is based on the waste water characteristics and treatment approach of the only existing latex foam plant. Briefly the model treatment system consists of chemical coagulation and clarification of latex-bearing waste waters and chemical precipitation of the zinc-laden rinse waters and biological treatment.

All latex-laden wastes can be isolated and sent to a chemical coagulation and clarification system. The system consists of two dual-purpose coagulation and clarification tanks. The tanks are filled, treated, and settled alternatively in a batch-wise manner. The latex wastes are first adjusted manually for pH using acid and alkali feed systems and then dosed with coagulating chemicals such as alum and polyelectrolyte. The coagulated latex solids are allowed to separate. Treatability studies will ascertain whether a "sinker", such as clay, is required. Floating latex solids can be skimmed from the water and screened. The filtrate water from the screen is returned to the treatment system and the screened solids are collected and hauled to a final disposal site. During the entire coagulation, settling, and emptying process the second identical tank is on-line and being filled.

Zinc-laden rinse waters are treated in another system simultaneously to the latex-laden wastes. The zinc wastes are pumped to rapid mix tank where lime and polyelectrolyte are added under vigorous mixing conditions. The pH of the waste water is raised and the solublized zinc is precipitated as insoluble zinc hydroxide. The precipitation process is concluded in a flocculation tank where the zinc hydroxide and lime solids agglomerate under mild agitation. The flocculated waste water flows to a clarifier where the zinc sludge settles out.

The clarified waste water is discharged with the clarified latex waste waters to a neutralization tank where the pH of the combined wastes are adjusted to the acceptable range for biological treatment (6.0 to 9.0 units).

The zinc-lime sludge is pumped to a holding tank prior to dewatering on a vacuum drum filter. The filtrate is returned to the mix tank and the filtered sludge is containerized prior to final disposal.

The performance of the latex waste water treatment system can be improved with good housekeeping and handling procedures as described for Subcategory J industries.

Effluent Loadings Attainable with the Control Technology

Subcategory J

Based on raw waste load and control and treatment data from Subcategory J plants, it was determined that the control and treatment technologies can achieve the following thirty day average effluent qualities:

BOD	30 mg/l
Suspended Solids	40 mg/l
Oil	15 mg/l
Chromium	0.05 mg/l
pH	6.0 to 9.0

The chromium limitation is included to ensure that those plants using chromic acid form-cleaning techniques do not discharge chromium containing wastes without adequate treatment.

The effluent waste loads resulting from the application of treatment technologies equivalent to chemical coagulation with clarification and biological treatment, constitute the best practicable control and treatment standards currently available for Subcategory J. Effluent limitations for BPCTCA are:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Oil and grease	2.0	0.73
BOD$_5$	3.72	2.20
TSS	6.96	2.90
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Oil and grease	2.0	0.73
BOD$_5$	3.72	2.20
TSS	6.96	2.90
pH	Within the range 6.0 to 9.0.	

In addition to the above limitations, discharges attributable to chromic acid form cleaning operations are subject to the following limitation.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Chromium	0.0086	0.0036
(English units)	lb/1000 lb of raw material	
Chromium	0.0086	0.0036

Subcategory K

The raw waste load and control and treatment data obtained from the only operating latex foam plant indicates that the recommended BPCTCA control and treatment technologies for latex foam production facilities are compatible with the following thirty day average effluent quality:

BOD	60 mg/l
Suspended Solids	40 mg/l
Zinc	3.5 mg/l
pH	6.0 to 9.0

This effluent quality can also be expressed in terms of effluent waste loads which are independent of waste water flow and dilution. These effluent waste loads, resulting from the application of treatment technologies equivalent to chemical treatment and clarification of both latex and zinc-laden waste waters and biological treatment, constitute the best practicable control and treatment technology standards currently available for the latex foam subcategory. Effluent limitations for BPCTCA are:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material	
Zinc	0.058	0.024
BOD_5	2.4	1.4
TSS	2.26	0.94
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of raw material	
Zinc	0.058	0.024
BOD_5	2.4	1.4
TSS	2.26	0.94
pH	Within the range 6.0 to 9.0.	

Variability Factors

For all pollutant parameters the daily maximum is greater than the monthly average. The ratio of daily maximum to monthly average is the variability factor. Available long-term data on the operation of the designed treatment systems (within the rubber and other industries) were statistically analyzed. Using 2.3 standard deviations, variability factors were derived for pollutants within each subcategory.

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE - EFFLUENT LIMITATIONS

General Molded, Extruded, and Fabricated Rubber Subcategories

Effluent limitations on oil and suspended solids applicable to the best available technology economically achievable (BATEA) and the best practicable control technology currently available (BPCTCA) are identical for general molded, extruded, and fabricated rubber subcategories. BPCTCA treatment reduces the prime pollutants, suspended solids, oil and grease, and lead to such a level that further treatment cannot be justified on a technical, cost or benefit basis.

Complete water reuse or elimination of contaminated waste waters, leading to zero discharge, is not universally feasible. Treatment of the waste water to approach influent-supply water quality in a reuse or recycle system requires removal of oils, suspended solids, total dissolved solids, and trace contaminants that cannot be substantiated on a technical, benefit, or cost basis. Some small-capacity manufacturing facilities (where the process waste water flow is small and slightly contaminated) can eliminate direct discharge to navigable waters by contract disposal or discharge to municipal systems. This will most probably be the most economic approach and will avoid costly discharge monitoring and reporting procedures.

Effluent Loading Attainable with Control Technologies

Limitations and standards for BATEA are identical to those for BPCTCA with the exception of the limitations for wet scrubbers. For BATEA wet scrubbing waters should be recycled and the blowdown settled prior to discharge. The BATEA limitations for wet scrubbing waters shall be as follows:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of raw material equivalent	
TSS	1.0	0.5

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(English units)	lb/1000 lb of raw material equivalent	
TSS	1.0	0.5

Wet Digestion Reclaimed Rubber Subcategory

The recommended treatment involves recycling of waste water streams and reclaiming of process oils. The proposed modification is illustrated schematically in Figure 9 (Section VII).

In a conventional wet digestion reclaiming process, the devulcanized rubber slurry leaving the digester is screened prior to drying, milling, and shipment. The dewatering liquor resulting from the screening operation is one of the principal waste water streams that can be recycled in part using the recommended BATEA technology.

The dewatering liquor is sent to an agitated storage tank from which it can be pumped back to the digestion make-up process.

At the same time, the cooling water and condensate from the barometric condensers on the blowdown tank and dryers are passed to a decant tank where the oil and separable organics are recovered. The bottom water layer is pumped to the agitated storage tank and is mixed with the dewatering liquor. The decant tank is equipped with an overflow line which controls the level in the decant tank. The overflow from this decant system discharges to the sewer.

The recovered oils and organics from the decant tanks are sent to a second oil decant and storage tank where the residual water content is removed from the oil and returned to the first decant tank. The reclaimed oils are then returned to the digester to be reused as digestion ingredients.

The dewatering liquor and water layer from the first decant tank are mixed in the water storage tank. The level of water in this tank is maintained and the excess water overflows to the sewer. The water storage tank is agitated in order to fully mix the various water streams and to suspend rubber fines and prevent their settling in the tank.

The net discharge from the wet digestion is reduced to the excess cooling and condensation waters from the blowdown tank and dryer vapor streams and the excess dewatering liquor. The flow and loadings of the combined discharge are lower than the effluent generated by a digestion process without the recycle system.

Effluent Loadings Attainable with Control Technologies

Further treatment of effluent waste waters beyond BPCTCA is not considered economically achievable by this economically marginal segment of the rubber industry. Future changes in the profit margin of reclaimers may warrant reevaluation, however, at this time BATEA limitations shall be equivalent to BPCTCA limitations.

Pan (Heater), Mechanical, and Dry Digestion Reclaimed Rubber Subcategory

For this subcategory, the effluent limitations recommended for the best available technology economically achievable are identical to those for the best practicable technology currently available.

Although it is not feasible to recycle or reuse entirely the process waste waters, direct discharge to navigable waters can be eliminated by employing the local municipal treatment system for the discharge of those waste waters which would benefit from secondary treatment. Contract haulage of contaminated waste is not generally feasible since the volumes involved in this industry are considerable.

Latex-Based Products

Subcategory J

Waste water pollutants are substantially reduced by BPCTCA. Further reductions of COD may be possible, however indications are that the effluent COD from biological treatment of latex dipped, molded, and extruded plants may be less than that for the Latex Subcategory (manufacture of latex rubber) after carbon adsorption. Unless further information is obtained, justifying additional treatment on an environmental and economic basis, BATEA shall be equivalent to BPCTCA.

It is possible in some cases to reduce the effluent loading by applying good-housekeeping and materials-handling procedures, such as the containment and reduction of latex washdown waters; however, the extent of the effect of these measures cannot be anticipated. Municipal systems can be used to treat the residual contamination of the process wastes, thereby eliminating direct discharge to navigable waters.

Subcategory K

The BATEA treatment (equivalent to BPCTCA) for the latex foam industry is based on studies made by the only operating latex foam plant in the industry. In brief, it involves biological treatment using an activated sludge process. The activated sludge process is selected in this instance since it is the most feasible and economic biological treatment approach (based on the high BOD loading of latex foam waste waters after primary treatment). The treatment system is schematically represented in Figure 12.

The primary treated latex-based wastes and the zinc-containing rinse waters (refer to Section IX) are discharged to an equalization basin where the contaminant levels are equalized prior to secondary treatment. The equalization basin is agitated to ensure good mixing and would provide approximately 8-hour detention, which is equivalent to one shift's operation. It is anticipated that the pH control facilities will be used to adjust the equalization influent pH to approximately 7 to ensure good biological activity and treatment.

The equalized waste water flows into the aeration basin where it is well mixed with biological solids. Micro-organisms synthesize new biological solids from organic matter contained in the waste water. At the same time, some soluble waste water constituents are consumed for energy purposes using oxygen supplied by aerators in the basin. The result is that soluble material is converted to insoluble biological solids and the BOD of the waste water is reduced. The mixed liquor containing biological solids suspended in the waste water overflows the aeration basins to the secondary clarifier.

The solids in the mixed liquor are settled in the secondary clarifier, and the clarified waste water overflows and enters an effluent monitoring station, where the flow, temperature, and pH are recorded and an automatic 24-hour composite sample is collected.

Part of the settled biological solids is returned to the aeration basins to maintain the mixed liquor solids concentration in the basin. The remainder of the bio-solids must be wasted from the system as a sludge.

The waste sludge is first thickened in a gravity thickener with the supernatant returning to the head end of the aeration basins. The thickened sludge underflow enters an aerobic digester, where the biological sludge is wasted by endogenous respiration to reduce the biosolid bulk. This process is referred to as aerobic digestion and requires oxygen which is supplied by aerators.

This digested biological sludge is then mixed with the zinc-lime sludge and further thickened in a secondary thickener. The clear supernatant from this thickener is recycled to the neutralization basin ahead of the equalization basin. The thickened underflow is then discharged to a vacuum filter for further conditioning, dewatering, and concentration.

A drum-type vacuum filter separates thickened sludge into:

1. A dewatered cake which is discharged by belt conveyor to a dumpster bin.
2. A filtrate that is recycled to the neutralization basin.

The dewatered sludge cake is biologically stable and can be disposed of to a sanitary landfill. Filter aid and precoat tanks, pumps and metering equipment may be required to assist and maintain the quality of the filtrate.

Effluent Loading Attainable with Control Technologies

Currently, there is only one known latex foam plant. This plant is negotiating to be permitted to discharge to a municipal system. Further analysis of technology beyond BPCTCA is considered unnecessary. It is doubtful that new plants will be built, other latex foam plants have existed, but were economically forced to close mainly from polyurethane completion. If other plants do begin to manufacture latex foam, a reevaluation of both BPCTCA and BATEA would be warranted. Process differences and plant size would be major factors to reconsider.

SECTION XI

NEW-SOURCE PERFORMANCE STANDARDS

Effluent Limitations

General Molded, Extruded, and Fabricated Rubber Subcategories

Effluent limitations for new sources are identical to the best practicable control technology currently available. These limitations are presented in Section X of this report. Sufficient pollutant reduction is obtained by BPCTCA limitations. At this time, further treatment would not be justified on a cost-benefit basis. A new plant may be designed to comply with stricter limitations and this will probably occur without stricter limitations. Some new plants, such as relocations, will not be economically capable of achieving further reduction in pollutant discharge, and therefore, no general reduction of BPCTCA limitations can be imposed upon new sources.

Wet Digestion Reclaimed Rubber Subcategory

Technological and economic restraints resulting from air and water pollution problems point to the eventual phasing out of the wet digestion process. According to industry spokesman, no new facilities using the wet digestion process are planned for the future. In fact, most companies using the process either have already changed or plan to change to the pan, dry digestion, or mechanical process. Accordingly, new-source performance standards shall be equivalent to best practicable control technology currently available. New reclaimed rubber facilities will probably utilize the pan, dry digestion, or mechanical process.

Pan (Heater), Mechanical, and Dry Digestion Rubber Reclaiming

Effluent limitations for new sources are identical to the best practicable control technology currently available. These standards and limitations are presented in Section IX of this report. No new process alterations are known at this time which would enable a new source to achieve stricter limitations.

Latex-Based Products Subcategory

Effluent limitations for Subcategory J and K, new sources are identical to the best practicable control technology currently available. These standards and limitations are presented in Section IX of this report. No new process alterations are known at this time which would enable a new source to achieve stricter limitations.

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Pretreatment Recommendations

A minimum level of pretreatment must be given to new production facilities which will discharge waste water to a publicly owned treatment works. In addition, potential pollutants which will inhibit or upset the performance of publicly owned treatment works must be eliminated from such discharge.

General Molded, Extruded and Fabricated Rubber Products Subcategories

Pretreatment controls for process waste waters from Subcategories E, F, and G facilities may include the separation of oils and solids in an API gravity separator and the use of an equalization basin to prevent shock loads of oil, suspended solids or batch dumps of dipping solutions from entering and upsetting the performance of a publicly owned treatment works. A limitation of 100 mg/l (daily maximum) for oil and grease is utilized by several municipalities, and has been accepted as a basis for this pretreatment regulation. In addition, lead-laden waste waters must be treated to BPCTCA levels prior to discharge.

Wet Digestion Reclaimed Rubber Subcategory

Pretreatment controls for process waste waters from Subcategory H facilities may include the separation of oils and solids and the use of an equalization basin to prevent shock loads. Separation of suspended solids and oil can be performed in a API-type separator if the waste water does not contain any digested fibrous material (i.e., the fiber is removed mechanically before digestion). If the fiber is digested along with the rubber scrap, the process waste water will contain large quantities of fibrous material, which are difficult to settle. Industry spokesmen indicate that a large sedimentation lagoon is adequate if the material is to be discharged to a municipal system. Such a lagoon should be designed to contain a 10-year, 24-hour rainfall event, as defined by the National Weather Service in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States," May 1961, and subsequent amendments.

Pan (Heater), Mechanical, and Dry Digestion Reclaimed Rubber Subcategory

As with Subcategories E, F, and G, pretreatment recommendations for process waste waters from Subcategory I facilities include separation of oils and solids. An equalization basin may be utilized to prevent shock loads of oil, suspended solids or batch dumps of processing solutions from entering and upsetting a municipal system.

Latex-Based Products Subcategory

Recommended pretreatment of process waste waters from Subcategory J and Subcategory K facilities include coagulation and clarification of solids-laden waste water. In addition, precipitation procedures are required to remove any chromium in Subcategory J waste waters and zinc in Subcategory K waste waters.

SECTION XII

ACKNOWLEDGMENTS

The original draft of this document was prepared by Roy F. Weston, Inc., West Chester, Pennsylvania, under the direction of Mr. Melvin J. Sotnick, Manager Chemical Engineering Services. He was assisted by David C. Day, PhD, Principal Engineer, Mr. Robert A. Morris, Chemical Engineer and other members of the staff.

The Environmental Protection Agency wishes to acknowledge the cooperation of the officers and plant personnel in the rubber industry who provided valuable assistance in the collection of data relating to process raw waste load and treatment plant performance at various rubber processing facilities. Special acknowledgment is made of Mr. Daniel G. Pennington of the Rubber Manufacturers Association for coordinating the schedule of visits among the industry members; also the assistance of personnel at the EPA Regional Centers who were contacted to identify plants in the rubber processing industry known to be achieving effective waste treatment. Special mention should be given to Herbert S. Skovonek, PhD, Edison Water Quality Research Laboratory Division of NERC, Cincinnati; Paul Ambrose, Enforcement Division, EPA Region III; John Lank, Enforcement Division, EPA Region IV; and Marshall Dick, Office of Research and Development, Headquarters.

In addition, special mention and acknowledgment is made of the following EPA rubber industry working group members who assisted in field sampling, project evaluation and review of the draft and final documents: Henry Garson, Legal Assistant, Effluent Guidelines Division; Richard Insinga, Planning and Evaluation, Economic Analysis Branch, Headquarters; Doris Ruopp, Office of Toxic Materials, Headquarters; Alan W. Eckert, Office of General Counsel; and Richard J. Kinch, Project Officer, Rubber Industry, Effluent Guidelines Division. Acknowledgment is made of the efforts of Barbara Wortman and Jane D. Mitchell, Effluent Guidelines Division for typing the final manuscript. Acknowledgment is made of the overall guidance and direction provided by Allen Cywin, Director and Ernst P. Hall, Deputy Director, Effluent Guidelines Division, and John E. Riley, Chief, Technical Analysis and Information Branch, and others within the Agency who provided many helpful suggestions and comments.

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SECTION XIII

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SECTION XIV

GLOSSARY

Accelerator Agent

A compound which greatly reduces the time required for vulcanization of synthetic or natural rubber.

Act

The Federal Water Pollution Control Act, as Amended.

Activator

A metallic oxide that makes possible the crosslinking of sulfur in rubber vulcanization.

Antioxidant

An organic compound added to rubber to retard oxidation or deterioration.

Anti-tack Agent

A substance used to prevent rubber stocks from sticking together during periods of storage.

Bag House

An air emission control device used to collect intermediate and large particles (greater than 29 microns) in a bag filter. (A bag filter constructed of fabric.) Common usage in the industry is to control and recover carbon black in a dry state from vapors leaving the compounding area.

Banbury Mixer

Trade name for a common internal mixer manufactured by Farrel Corporation used in the compounding and mixing of tire rubber stock.

Best Available Demonstrated Control Technology (BADCT)

Treatment required for new sources as defined by Section 306 of the Act.

Best Available Technology Economically Achievable (BATEA)

Treatment required by July 1, 1983 for industrial discharges to surface waters as defined by Section 301 (b) (2) (A) of the Act.

Best Practicable Control Technology Currently Available (BPCTCA)

Treatment required by July 1, 1977 for industrial discharges to surface waters as defined by Section 301 (b) (1) (A) of the Act.

BOD5

Biochemical Oxygen Demand (5 day).

Butyl Rubber

A synthetic rubber made by the solution polymerization of isobutylene and isoprene.

Camelback

Tire tread used in the retreading of tire carcasses.

Capital Costs

Financial charges in August 1971 dollars which are computed as the cost of capital times the capital expenditures for pollution control. Cost of capital is assumed to be 10 percent.

Carbon Black

A reinforcing agent used in large quantities in rubber compounds.

Catalyst

A substance that initiates a chemical reaction and enables it to proceed at a greatly accelerated rate.

Cement

A process stream consisting of polymeric rubber solids dissolved in solvent.

Coagulation

The combination or aggregation of previously emulsified particles into a clot or mass.

COD

Chemical Oxygen Demand.

Crumb

Small coagulated particles of synthetic rubber.

Curing Agents

Curing or vulcanization agents are substances which bring about the rubber crosslinking process. The most important agent is sulfur. (See vulcanization.)

Depreciation

Accounting charges reflecting the deterioration of a capital asset over its useful life. Reported as straight line over five years with zero salvage value.

Devulcanization

The term is used to describe the softening of a vulcanizate by heat and chemical additives during reclaiming.

Dry Air-Pollution Control

The technique of air pollution abatement without the use of water.

Emulsion

A stable mixture of two or more immiscible liquids held in suspension by small percentage of substances called emulsifiers.

Endogenous Respiration

Auto-oxidation of the microorganisms producing a reduction and stabilization of biological solids.

EPDM

A synthetic rubber based on ethylene-propylene and a controlled amount of non-conjugated diene. Polymerization is carried out in solution.

Extender

A low specific gravity substance used in rubber formulations chiefly to reduce costs.

Extrude

To shape by forcing a material through a die. The operation is carried out in a device known as an extruder.

Filler

A high specific gravity (2.00-4.50) compound used in rubber mixtures to provide a certain degree of stiffness and hardness and used to decrease costs. Fillers have neither reinforcing or coloring properties and are similar to extenders in their cost-reducing function.

Flash

The overflow of cured rubber from a mold.

gpm

Gallons per minute.

IR

Polyisoprene rubber, the major component of natural rubber, made synthetically by the solution polymerization of isoprene.

Investment Costs

The capital expenditures reported in August 1971 dollars required to bring the treatment or control technology into operation. Included are expenditures for design, site preparation, purchase of materials, construction and installation. Not included is the purchase of land on which the system is to be built.

L

Liter

Latex

A suspension of rubber particles in a water solution. Coagulation of the rubber is prevented by protective colloids. A protective colloid is a surface-active substance that prevents a dispersed phase of a suspension from coalescing by forming a thin layer on the surface of each particle.

Masterbatch

A compounded rubber stock applicable to a wide variety of uses. Main ingredients are rubber, carbon black and extender oil.

mg/l

Milligrams per liter.

Modifier

An additive which adjusts the chain length and molecular weight distribution of the rubber during polymerization.

Monomer

A compound of a relatively low molecular weight which is capable of conversion to polymers or other compounds.

NBR

Nitrile rubber, a synthetic rubber made by emulsion polymerization of acrylonitrile with butadiene.

New Source

Any building, structure, facility, or installation from which there is or may be a discharge of pollutants and whose construction is commenced after the publication of the proposed regulations.

Non-Productive Rubber Stock

Rubber stock which has been compounded but which contains no curing agents. Synonym for non-reactive rubber stock.

Non-Reactive Rubber Stock

Rubber stock which has been compounded but which contains no curing agents. Synonym for non-productive rubber stock.

Operations and Maintenance

Costs required to operate and maintain pollution abatement equipment. They include labor, material, insurance, taxes, solid waste disposal, etc.

PBR

Polybutadiene rubber, a synthetic rubber made by solution polymerization of butadiene.

pH

A measure of the relative acidity or alkalinity of water. A pH of 7.0 indicates a neutral condition. A greater pH indicates alkalinity and a lower pH indicates acidity.

Pigment

Any substance that imparts color to the rubber. Pigment substances such as zinc oxide or carbon black also act as reinforcing agents.

Plastic

Capable of being shaped or molded with or without the application of heat.

Process Water

All waters that come into direct contact with the raw materials and intermediate products.

Productive Rubber Stock

Compounded rubber which contains curing agents and which can be vulcanized. Synonym for reactive rubber stock.

Raw Material Equivalent

The term raw material equivalent shall be equal to the raw material usage multiplied by the volume of air scrubbed via wet scrubbers divided by the total volume of air scrubbed.

Reactive Rubber Stock

Compounded rubber which contains curing agents and which can be vulcanized. Synonym for productive rubber stock.

Reclaimed Rubber

Depolymerized (plasticized) scrap rubber, either natural or synthetic.

Reinforcers or Reinforcing Agents

Fine powders used to increase the strength, hardness and abrasion resistance of rubber. Reinforcing agents used in the rubber processing include carbon black, zinc oxide, and hydrated silicas.

Rotacure

Trade name for a common curing press.

SBR

Styrene butadiene rubber. A synthetic rubber made either by emulsion or solution polymerization of styrene and butadiene.

Soapstone

A substance used to prevent rubber stocks from
sticking together during periods of storage. Used in both a dry and solution form. The major ingredient is usually clay.

Solution

A uniformly dispersed mixture at the molecular level of one or more substances in one or more other substances.

Stripper

A device in which relatively volatile components are removed from a mixture by distillation or by passage of steam through the mixture.

Subcategory

A division of a particular industry which possesses different traits which affect water quality and treatability.

Surface Waters

The waters of the United States including the territorial seas.

Vulcanization

Vulcanization is the process by which plastic rubber is converted into the elastic rubber or hard rubber state. The process is brought about by linking of macro-molecules at their reactive sites.

Wet Air-Pollution Control

The technique of air pollution abatement utilizing water as an absorptive media.

TABLE 44

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS) by TO OBTAIN (METRIC UNITS)

ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555(°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
ton (short)	ton	0.907	kkg	metric ton (1000 kilograms)
yard	yd	0.9144	m	meter

* Actual conversion, not a multiplier

☆ U.S. GOVERNMENT PRINTING OFFICE: 1975— 582-421/255